SCOPES 2010 -2013

Guidelines for scientific reports (JRP/IP)

The report must be submitted to the SNSF by the project co-ordinator (**electronically and in print**). It should cover **the whole period since the start of the project**.

1. General Information

1.1 Title of the JRP/IP: Synthesis of heavy elements in core collapse supernovae and their imprint on galactic chemical evolution

1.2 Number of the JRP/IP: IZ73Z0 128180

1.3 Name of co-ordinator and partner teams:

Principal Applicant: Thielemann, Friedrich-K., Basel

Co-applicant(s):

Charbonnel, Corinne, Versoix/Geneva

Mishenina, Tamara V., Odessa

Panov, Igor V., Moscow

2. Overview of (research) activities

2.1 Which work has been carried out by each of the teams?

Have the activities been in accordance with the scientific and technical description in the application?

The summary of the original proposal described a number of related topics to be addressed for the duration of our Scopes Project. During the 3.75 years of the work, relying on this initially established, extended plan, we made progress in all of the following astrophysical subprojects:

- hydrodynamic (neutrino-)radiation transport calculations of core-collapse supernovae with new presupernova models(milestone 2);
- Numerical simulations of shock-breakout in supernovae, based on multigroup radiation transfer, coupled to hydrodynamics (milestone 7b);
- neutrino-induced nucleosynthesis and the influence of neutrinos on the production of nuclei beyond Fe in proton-rich environments in the innermost ejected zones, as well as on the outer zones dominated by the neutrino-nuclear spallation;
- Equation of state descriptions at extreme densities, combining the quark-hadron phase transition, an excluded-volume approximation, as well as the inclusion of light clusters, were developed for the implementation in supernova simulations. (milestone 2 and additional activities beyond originally planned tasks);
- extension of the calculations until late times when the neutrino-driven wind might provide conditions which support the r-process to produce the heaviest nuclei and testing alternatives like polar jet-ejection in rotating models (including magnetohydrodynamic effects) or neuron star mergers (milestone 3b);
- consistent r-process calculations for the main r-process scenario which include fission and testing the influence of nuclear masses/fission barriers and other predictions of nuclear properties on the formation of superheavy elements (milestone 3b);
- Using phenomenological approaches to spontaneous fission and its application to the r-process. Testing the influence of models for spontaneous fission rates and other predictions of nuclear properties on the formation of superheavy elements (milestones 1 and 3a);
- modeling of non-LTE line formation for heavy elements in stellar atmospheres (milestones 4,7a);

- determination of element abundances in old stars over a large range of metallicities and thus providing a data base for changes in abundance ratios of heavy (neutron-capture) elements during the evolution of the Galaxy (milestone 5);
- Determination of stellar ages for different metallicities via the decay pattern of actinide abundances (milestone 5);
- galactic chemical evolution calculations, based on the ejected abundance yields from the nucleosynthesis predictions, and comparison with observations obtained from the investigations, testing the enrichment pattern of stellar populations in the Galaxy at different evolutionary times and distances (milestone 6 and 5).

These actitvities were part of seven milestones mentioned in the original proposal:

Milestone	**Associated activity**	**Expected duration**	**Responsible project partner**	**realized percentage**
1a	Neutron-induced reaction rates	1 year	Partner 1,3	100
1b	Spontaneous and delayed fission	1 year	Partner 1,3	100+
2	Neutrino transport and supernova models	3 years	Partner 1,3	~100
3a	Phenomenological tests for nucleosynthesis	2 years	Partner 1,3	100+
3b	Nucleosynthesis in consistent models	3 years	Partner 1,3	100*
4	atomic input for spetrum modeling	2 years	Partner 2,3,4	100
5	abundance determination from spectra	3 years	Partner 2,3,4	>100
6	incorporation of nucleosynthesis predictions in chemical evolution models	3 years	Partner 2	100
7a	Different NLTE effects	2 years	Partner 3,4	100
7b	shock-breakout with relativistic effects	2 years	Partner 1,3	100

*** 1=Basel; 2=Geneva; 3=Russian partner; 4=Ukrainian partner**

The results obtained by the research project, emphasizing results obtained in 2012-2013, are summarized in the following, also indicating the connection to the milestones listed above. For some subprojects we were able to perform all required studies and even obtained results beyond the initial intentions. The extension of the grant duration beyond 2012 also permitted to published most of the results elaborated in 2012. For other subprojects, especially the supernova models, the goal of obtaining successful explosions was eventually attained, but too late to fully explore these results in consistent nucleosynthesis calculations. Therefore milestone 3b relates to consistent models for neutron star mergers and jet ejecta of fast rotating models with high magnetic fields, but nucleosynthesis calculations of regular core-collapse supernovae were still performed in a phenomenological approach. The indices I through VII are not always directly linked to the milestones repeated here, but rather relate to subgroups of all four participating institutions. I and II cover observations and their analysis by groups at Odessa and Moscow observatories, III-V relate to activities perfomed at ITEP Moscow, VI and VII list the contributed activities of the Basel and Geneva groups. As the support for Basel and Geneva is mostly related to travel and the exchange of ideas with the groups from eastern Europe, the latter two activities are presented in a shorter way and more selectively. They appear anyway as part of annual reports of the regular SNF grants of these groups. But we mention specifically the projects of joint nature, where a real collaboration got started.

I. The Galaxy: Chemical evolution studies and NLTE effects

All the planned individual tasks of L. Mashonkina, A. Velichko (2010), and T. Sitnova (2011-2012) have been finished successfully. An exception is the task for the non-equilibrium line formation calculations for Dy II/III. It was replaced by three different ones, important for understanding stellar nucleosynthesis and chemical evolution of the Galaxy: (I) non-local thermodynamic equilibrium (NLTE) line formation calculations for Pb I, (ii) NLTE line formation calculations for Th II, and (iii) updating NLTE line formation calculations for O I.

I.1 NLTE line formation calculations for Pb I, Th II, and Cu I and updated the method of NLTE calculations for O I (L. Mashonkina and T. Sitnova).

A comprehensive model atom for Pb I was constructed for the first time. Atomic data on energy levels and transition probabilities were taken from laboratory measurements and atomic structure calculations. The NLTE calculations for Pb I were performed for a grid of model atmospheres with effective temperatures T_{eff} = 4000-6000 K, surface gravities log g = 0-4.6, and various metallicities [Fe/H] = -0.6 to -3. NLTE leads to systematically depleted total absorption in the Pb I lines and accordingly, positive abundance corrections Δ_{NLTE}. The departures from LTE grow with decreasing metallicity, such that Δ_{NLTE} of Pb I 4057 Å increases from 0.16 dex in the 5780/4.44/0 model up to 0.56 dex in the 4825/1.5/-2.9. The NLTE method was applied to revise the solar Pb abundance. With the Holweger & Mueller (1974) model atmosphere, we determined log ε_{Sun}(Pb) = 2.09, in good agreement with the meteoritic abundance log ε_{met}(Pb) = 2.06 (Lodders et al. 2009). For comparison, an element abundance lower by 0.13 dex was obtained utilizing LTE assumptions.

We also built for the first time a model atom for singly-ionized thorium. The NLTE calculations for Th II were performed for the Sun and a the small grid of model atmospheres with [Fe/H] = -2 and -3. In contrast to Pb I, Th II is a dominat species in the stellar parameter range that we have covered, and the main NLTE mechanism for Th II is connected to pumping transitions arising from the low-excitation levels, with E_{exc} < 1 eV. Overall, NLTE leads to weakened Th II lines and positive NLTE abundance corrections, however, Δ_{NLTE} nowhere exceeds 0.21 dex.

A comprehensive model atom for Cu I was constructed in collaboration with Jianrong Shi. It was found that the statistical equilibrium of Cu I in solar-type atmospheres is subject to the ultraviolet overionization, resulting in systematically depleted total absorption in lines of Cu I and positive abundance corrections. As a first application of the Cu I model atom, the solar copper abundance was determined on the basis of a classical 1D (MAFAGS-OS) solar model atmosphere. With experimental gf-values of Kock & Richter (1968, Z. Astrophys., 69, 180), the five low-excitation (E_{exc} = 0-1.64 eV) lines of Cu I reveal a 0.16 dex lower abundance compared with that from the five E_{exc} > 3.7 eV lines. For the latter group, the mean NLTE abundance is log ε_{Cu}=4.26±0.05, in good agreement with the meteoritic value log ε_{met}=4.27 of Lodders et al. (2009, in Trumpler, J.E. (ed.) Landolt-Börnstein. New Series, Astronomy and Astrophysics, vol. VI/4B, p. 560. Springer, Berlin). No discrepancy between low- and high-excitation lines was found when applying predicted gf-values, with the mean log ε_{Cu} = 4.22±0.09 from 11 lines.

The NLTE calculations for O I were performed using accurate electron-impact excitation rates from Barklem (2007). It was shown that the difference in NLTE abundance between the infrared O I 777.1-777.5 nm and visible lines in reference A-type stars with well determined parameters reduces significantly compared with that for LTE. In case of Procyon and the Sun, inelastic collisions with H I atoms affect the statistical equilibrium of O I, and agreement between the abundances from different lines is achieved, when using Drawin's classical formalism. The solar oxygen mean NLTE abundance is log ε = 8.74±0.05, when using a classical plane-parallel solar model atmosphere and log ε = 8.78±0.03 plus applying the 3D corrections taken from Caffau et al. (2008). The NLTE abundance corrections have been calculated for the grid of model atmospheres with stellar parameters characteristic of solar-type stars.

This sub-summary indicates a strong progress for milestones 4 and 7a.

I.2 L. Mashonkina, A. Velichko (2010), and T. Sitnova (2011-2013) determined stellar parameters and chemical abundances of selected halo stars with metallicities between [Fe/H] = -1.5 and -4.9 using high-resolution UVES/VLT spectra.

HE 2327-5642 is a strongly r-process enhanced and very metal-poor giant star with [Fe/H] = -2.78. The effective temperature T_{eff} = 5050 K was obtained from Balmer line wing fits and photometric color calibrations. The gravity log g = 2.34 was calculated from the NLTE ionization balance between Fe I and Fe II, and Ca I and Ca II. Accurate abundances were determined for a total of 40 elements and for 23 neutron-capture elements beyond Sr and up to Th. The mean [r/Fe] = 0.99±0.03 was found for the seven nearly pure r-process elements from Eu to Tm. For HE 2327-5642, elements in the range from Ba to Hf match the scaled solar r-process pattern very well suggesting that a production ratio of these elements is universal during the Galaxy history. This is in line with the results obtained previously for other strongly r-process enhanced (r-II) stars such as CS 22892-052, CS 31082-001, and HE 1219-0312. This proves that HE 2327-5642 is an r-II type star. No firm conclusion can be drawn with respect to a relationship between the first neutron-capture peak elements, Sr to Pd, in HE 2327-5642 and the solar r-process, due to the uncertain origin of the latter in this mass range.

HD29907 is a halo and mildly metal-deficient star, with [Fe/H] = -1.55. Accurate abundances were determined for a total of 20 neutron-capture elements beyond Sr and up to Yb. It was found that the star has a moderate r-process enhancement with [r/Fe] = 0.63 and elements in the range from Ba to Yb match the scaled solar r-process pattern very well. This gives strong support for a nearly pure r-process production of elements in the range from Ba to Yb at the epoch with [Fe/H] = -1.55, when the star formed.

SDSS J102915+172927 is the 4th most iron-deficient star currently known, with [Fe/H] = -4.9. The chemical analysis of extremely metal-poor stars permits a better understanding of the formation of the first generation of stars. With T_{eff} = 5810 K and log g = 4.0, chemical abundances were determined based on the NLTE line formation for Mg I, Si I, Ca I-Ca II, Fe I-Fe II, and Sr II. Calcium is the only element observed in SDSS J102915+172927 in two ionization stages, and it can serve to constrain the star's surface gravity. The ionization equilibrium between Ca I and Ca II is attained for log g = 4.5, which is consistent within the error bars of the photometric gravity. When taking both the NLTE and 3D effects into account, the revised iron abundance is [Fe/H] = -4.89. The abundance pattern was found to be different from that of galactic halo stars, namely, Mg and Ca do not reveal any significant enhancement relative to Fe, but there exists a strong enhancement of Si, with [Si/Fe] = 0.7. Together with the absence of any signatures of C, N, and O the obtained results are a challenge for the Galaxy chemical evolution theory.

I.3 L. Mashonkina investigated evolutionary changes in abundance ratios between neutron-capture elements in a few samples of cool stars.

The Sr/Eu and Zr/Eu abundance ratios were inspected in a pre-selected sample of 53 halo stars with a dominant contribution of the r-process to the production of heavy elements beyond Ba, i.e., with [Ba/Eu] < -0.5. A clear distinction in these ratios between the stars of different Eu enhancement was found. The 9 stars, whose stellar matter presumably has experienced a single nucleosynthesis event ([Eu/Fe] > 1), have log(Sr/Eu) = 1.48±0.13. The other stars of lower Eu enhancement, with 0.2 < [Eu/Fe] < 1 (32 stars) and [Eu/Fe] < 0 (12 stars), have twice or respectively nearly an order of magnitude higher Sr/Eu ratios, suggesting in the early Galaxy a production mechanism for the light trans-iron elements, which is different from the r-process.

Abundances of Pb and Eu were revised for the metal-poor stellar sample of Roederer et al. (2010) based on the NLTE line formation. It was found that the two strongly r-process enhanced stars have very similar Pb/Eu abundance ratios, with the mean log ε(Pb/Eu) = 0.68±0.01, being well reproduced by the waiting-point r-process model of Kratz et al. (2007). The revised Pb/Eu abundance ratios of the r-II stars match, within the error bars, the corresponding solar r-process ratio. Thus, the universality of the r-process has been proven not only for the second r-process peak elements from Ba to Hf as found earlier (see Sneden et al. 2008, ARAA, 46, 241 and references

therein), but also for the heavier element Pb. The stars in the -2.3 < [Fe/H] < -1.4 metallicity range have, on average, 0.51 dex higher Pb/Eu abundance ratios than that of the strongly r-process enhanced stars. We conclude that the s-process production of lead started as early as [Fe/H] = -2.3. The average Pb/Eu abundance ratio of the mildly metal-poor stars, with -1.4 ≤ [Fe/H] ≤ -0.59, is very close to the corresponding solar system value, in line with the theoretical predictions of Travaglio et al. (2001, ApJ, 549, 346) that AGB stars with [Fe/H] ≈ -1 provide the largest contribution to the solar abundance of s-nuclei of lead.
Points 2 and 3 indicate major advances in milestones 5 and 7a.

I.4 Based on high quality spectral observations (spectral resolving power R ≈ 60000) in the wavelength range 355–500 nm, Mishenina and Korotin determined the four basic stellar parameters effective temperature, surface gravity, microturbulence velocity, and chemical abundances, including heavy metals from Sr to Dy for 14 metal–deficient G–K stars with high proper motions. The high resolution spectra were taken at the 6m telescope of the Special Astrophysical Observatory of the Russian Academy of Sciences. The stars studied have metallicities from [Fe/H] = −0.3 down to −2.9. Abundances of Mg, Al, Sr, and Ba were calculated based on NLTE line-formation. The abundances of Th and the r–process element Eu were determined through synthetic spectrum calculations. The stars from different galactic populations chosen by the kinematical criterion were selected, and it was found that the high proper motion stars belong to different components of the Galaxy: thin, thick disks and halo. The chemical composition of the star BD+80◦ 245, located far from the galactic plane, is in line with its belonging to the accreted halo. For the giant HD115444 we obtained [Fe/H] = −2.91, an underabundance of Mn, an overabundance of heavy metals from Ba to Dy, and especially a high excess of the r–process element europium: [Eu/Fe]=+1.26. Contrary to its chemical composition typical for halo stars, HD115444 belongs to the disc population according to its kinematic parameters. Estimation of the stellar age from Th/Eu ratio was made and a large scatter in age values was found.

I.5 Korotin, Mishenina, and Gorbaneva have determined barium abundances of 173 dwarf stars belonging to the thin and thick disks, taking into account NLTE effects for the unblended Ba II lines 4554, 5853, 6496 A. The line 6141 A was also used, by taking into account an influence of the iron line. We used a modified version of the MULTI code and the atomic model of the Ba atom with 31 levels of Ba I and 101 levels of Ba II. The average barium abundances of the thin and thick disc stars are 0.01 ± 0.08 and −0.03 ± 0.07, respectively. A comparison to the Galactic chemical evolution calculations by Serminato et al. was conducted. The trend obtained for the Ba abundance versus [Fe/H] suggests a complex barium production process in the thin and thick discs.

I.6 Using the original atomic model of Sr II, Korotin obtained the NLTE abundance of strontium in a sample of 54 very or extremely metal-poor halo stars. It was shown that in the early Galaxy additional sources of Sr production are required, in addition to those responsible for the production of Ba.

I.7 Andrievsky, Korotin, and Mishenina studied the effects related to departures from LTE as well as homogeneity in the atmospheres of red giant stars, in order to assess the influence on the formation of Ba II lines. They estimated the effect on barium abundance determinations for 20 red giants in the Galactic globular cluster NGC 6752. One-dimensional (1D) LTE and NLTE barium abundances were derived using classical ATLAS9 stellar model atmospheres. Three-dimensional (3D) LTE abundances were obtained for 8 red giants on the lower RGB by adjusting their 1D LTE abundances using 3D–1D abundance corrections, i.e., the differences between the abundances obtained from the same spectral line using 3D hydrodynamic and classical 1D stellar model atmospheres. The 3D–1D abundance corrections were obtained in a strictly differential way, using the 3D hydrodynamic and classical 1D codes CO5BOLD and LHD. Both codes utilize identical stellar atmospheric parameters, opacities, and equation of state. The mean 1D barium-to-iron abundance ratios derived for 20 giants are [Ba/Fe] = 0.24 ± 0.05(stat.) ± 0.08(sys.) in LTE and [Ba/Fe] = 0.05 ± 0.06(stat.) ± 0.08(sys.) in NLTE. The 3D–1D abundance correction obtained for 8 giants is small (+0.05 dex) and, thus, leads to an only minor adjustment. When applied to the mean 1D NLTE barium-to-iron abundance ratio for the 20 giants, [Ba/Fe](3D+NLTE) = 0.10 ± 0.06(stat.) ± 0.10(sys.) is obtained.

I.8 Mishenina, Pignatary, Korotin, Charbonnel, Thielemann, Gorbaneva, and Basak have analyzed the behavior of the α-element (O, Mg, Si, Ca), iron peak (Fe, Ni), and neutron-capture element (Y, Zr, Ba, La, Ce, Nd , Sm and Eu) abundances for 276 FGK dwarfs with metallicities -1 < [Fe/H] < +0.3, located in the galactic disk. They assigned most of the stars in the sample to the substructures of the Galaxy thick disk, thin disk or Hercules Stream, according to their kinematics. The classification of 27 stars is uncertain. For most of the stars in this sample the abundances of neutron-capture elements were not measured previously. For all of them, the chemical composition was determined, and the contribution from different nucleosynthesis processes was discussed. As expected, the trend of the α-elements with respect to iron decreases in both disks and in the Hercules stream, due to the SNIa chemical contribution. The [Ni/Fe] ratio shows a flat value close to solar over the whole metallicity range, with a small scatter, pointing to a nearly solar Ni/Fe ratio in the ejecta of both core collapse SN and SNIa. The increase in [Ni/Fe] for metallicities higher than solar is confirmed, and it is due to the metallicity dependence of ^{56}Ni ejecta from SNIa. With a large uncertainty in age determinations of observed stars, we find a large dispersion in the AMR in the thin disk and no clear trend, as in the thick disk. That may be one of the main reasons for the dispersion, observed for the s-process elements in the thin disk (e.g., Ba and La), whereas much a narrower dispersion can be seen for the r-process elements (e.g., Eu). Within the current uncertainties, there is no clear decreasing trend of [Ba/Fe] or [La/Fe] with metallicity in the thin disk, except maybe for super-solar metallicities. There is no increase in the mentioned ratios with decreasing stellar age. This important result was obtained in the joint research of the chemical composition (Odessa; Ukraine) and theoretical calculations of stellar evolution and nucleosynthesis (Basel, Geneva; Switzerland).

I.9 Andrievsky, Korotin, and Kovtyukh derived the barium atmospheric abundances for a large sample of cepheids, comprising 270 stars. The sample covers a large range of galactocentric distances, from about 4 to 15 kpc, so that it is appropriate to investigate the existence of radial barium abundance gradients in the galactic disc. In fact, this is the first time that such a comprehensive analysis of the distribution of barium abundances in the galactic disc is carried out. As a result, we conclude that the Ba abundance distribution can be characterized by a zero gradient. This result is compared with derived gradients for other elements, and some reasons are briefly discussed for the independence of the barium abundances upon galactocentric distances. This result may have significant impact on the existing models of the Galactic chemical evolution, because up to now there was no possibility to take into account the barium abundance gradient as an input parameter in such models.

Points 4-9 underline the progress made for milestone 5 and 7a.

I.10 In addition to the previous plan of the project, the following investigations of NLTE effects and Galactic chemical evolution were pursued as a basis for further work.

I.10.1 Abundances of copper, zinc, sodium, aluminum were determined for 172 F-, G-, K-dwarfs (-1.0 < [Fe/H] < 0.3), belonging to the thin and thick disks and the Hercules stream. The Cu abundances and their trends with metallicity are essentially the same in the three studied sub-structures. The mean Al and Zn abundances for stars of the thin and thick disks differ significantly (Mishenina, Gorbaneva).

I.10.2 Mishenina, Korotin, and Kovtyukh measured the abundance of yttrium and barium of eight distant open clusters, namely Ruprecht 4, Ruprecht 7, Berkeley 25, Berkeley 73, Berkeley 75, NGC 6192, NGC 6404, and NGC 6583. It was confirmed that barium is indeed overabundant in most clusters, especially, young clusters. Finally, we investigated the trend of yttrium and barium abundances as a function of distance in the Galaxy and stellar age. Several scenarios for the barium overabundance are then discussed. In particular, we note that Ruprecht 7, besides showing a net overabundance, also possesses an abnormal orbit according to the calculations by Vande Putte et al. (2010) and Gozha, Borkova & Marsakov (2012). Unfortunately, however, the accuracy in the orbit determination (large proper motion errors for distant clusters and the adopted fixed Galactic potential) does not allow us to further explore the possible consequences of this result.

I.10.3 Using high-resolution spectra, Chekhonadskih and Kovtyukh studied 31 yellow supergiants in the Large and Small Magellanic Clouds with atmospheric models. Abundances of 20 chemical elements were determined. It is shown that α-elements are in a slight excess and neutron-capture elements have an excess up to 0.60 dex. Approbation of a new technique for the determination of absolute stellar magnitudes of late-type supergiants is performed. The technique is based on the use of a spectroscopic criterion, namely, depth-line ratios for iron. Absolute stellar magnitudes of nine supergiants in the Large Magellanic Cloud are calculated on the basis of this technique. The distance modulus of the Large Magellanic Cloud is estimated as m – M = 18.4 ± 0.3m.

I.10.4 Andrievsky, Korotin, and Kovtyukh derived oxygen abundances in a large sample of cepheids using the O I near IR triplets from a NLTE analysis and compared those abundances to values derived from an LTE analysis of the [O I] 630.0 nm line and the O I 615.7 nm triplet, as well as LTE abundances for the 777.4 nm triplet. All these lines suffer from line strength problems making them sensitive to either measurement uncertainty (weak lines) or line saturation difficulties (strong lines). Upon this realization, the LTE results for the [O I] lines and the O I 615.7 nm triplet are in adequate agreement with the abundance from the NLTE analysis of the near IR triplets.

Points 10.1 – 10.4 underline the progress made for milestone 5.

II. Chemical abundances as a tool to investigate physical properties of stars

II.1 Mishenina and Kovtyukh have obtained the stellar parameters and Li abundances for 150 slow rotating stars of the lower part of the main sequence. The studied stars show a decline in the Li abundance with decreasing temperature T_{eff} and a significant spread, which should be due to the difference in stellar age. The correlations between the Li abundances, rotational velocities v sin i, and the level of the chromospheric activity were obtained for stars with 6000 > T_{eff} > 5700 K, and it are tighter for the stars with 5700 > T_{ef}f > 5200 K. The target stars with T_{eff} < 5200 K do not show any correlation between log A(Li) and v sin i. The relationship between the chromospheric and coronal fluxes in active stars with detected Li as well as in less active stars gives a hint that there exist different conditions in the action of the dynamo mechanism in those stars. It was found that the Li-activity correlation is evident only in a restricted temperature range and the Li abundance spread seems to be present in a group of low chromospheric activity stars that also show a broad spread in the chromospheric vs. coronal activity.

II.2 To identify the pulsation mode of the three low-amplitude classical cepheids V1334 Cyg, V440 Per, and V636 Cas, Chekhonadskih and Kovtyukh used absolute magnitudes which are based upon M_v - Fe II/Fe I line depth relations. They determined that V1334 Cyg is pulsating in the first overtone, while V440 Per and V636 Cas are fundamental mode pulsators. Their low amplitudes are due to their position close to the edge of the instability strip.

II.3 Andrievsky and Korotin derived stellar parameters and chemical element abundances of the four stars VW Dra, FT Cnc, VV LMi, and MQ Hya, classified as semi-regular variables of type “d” (SRd). These stars should presumably belong to the Galactic halo population, however, their chemical composition is inconsistent with their status of metal-deficient halo giants. All studied SRd giants have relative-to-solar elemental abundances that are typical of the thick/thin Galactic disk stars. Andrievsky and Korotin found that all objects of this class for which spectroscopic follow up analyses have been completed show a dichotomy in the amplitudes of their photometric variations. Specifically, the disk objects have small amplitudes, while halo SRd stars have much larger amplitudes, which indicates that the amplitude is obviously related to the metallicity of the star.

II.4 Yushchenko investigated the binary star ZZ Boo. The atmospheric parameters of the components were found, using the published photometric observations and the abundance analysis of iron lines: the flux ratio of the components FA/F B = 1.12 ± 0.15, the effective temperatures of the components T_{eff} = 6860 ± 20 K and 6930 ± 20 K, the surface gravities log g = 3.72 ± 0.10 and 3.84 ± 0.10, the metallicities [Fe/H] = −0.10 ± 0.08 and −0.03 ± 0.10, and the projected rotation velocities v sin i = 11.9 ± 0.4 km s^{-1} and 19.3 ± 0.8 km s^{-1} for the primary and secondary components, respectively. The given errors are formal errors of the methods used; the systematic errors of the temperatures, gravities, metallicities, and projected rotational velocities can be as high as 250–300 K, 0.3 dex, 0.15 dex, and 4 km s^{-1}, respectively. Abundances of 24 and 22 chemical elements were determined. The abundance pattern of the primary component shows solar or slightly under-solar abundances for all elements. The CNO abundances are close to solar values. The abundance pattern of this component resembles those of λ Boo type stars. The abundances of light elements, except oxygen, in the atmosphere of the secondary component are practically solar. The abundances of barium and two detected lanthanides are close to solar values; the overabundance of oxygen is 0.9 dex. The abundances of the two components are evidently different. The comparison of relative abundances with the condensation temperatures and second ionization potentials of the elements confirms the difference in abundance patterns and allows the discussion of different accretion scenarios for the two components of this binary system.

II.5 The hydrogen line and other strong lines in the 5900-7100 Å region of the spectrum of RM_1-667 (sectral type K7 I) were analyzed. They show the presence of mass outflow from the star with a significant velocity. Using the iron lines and the model atmospheres of supergiants (T_{eff} = 3750 K – 4300 K) from Kurucz‘s grid, Yushchenko obtained the iron abundance lg ε (Fe) = 6.75-7.08, which is equivalent to [Fe/H] = -0.75 to -0.42.

II.6 Chekhonadskih worked out an architecture of the database (the software database - MySQL, Interface – Asp.net), web interface, and the system of multiuser and multigroup access to the database. There is a link to the pre-beta-version: http://81.25.229.30:8888/Default.aspx. Currently the database includes the atmospheric parameters and abundances of 20 elements for 1200 stars belonging to the halo, thin and thick disks of our Galaxy.

III. Nuclear data, fission and nucleosynthesis

III.1 The conditions in neutron star merger (NSM) ejecta lead to high ratio n/seed ratios, sufficient for a strong r-process and the formation of high amounts of actinides among other heavy nuclei. In such a scenario different fission modes, in addition to neutron-induced fission, become important and lead to fission cycling. This way, fission products act again as seeds for an r-process and the formation of elements with A>100. Spontaneous fission lifetimes of transactinide nuclei can be extremely short and can hinder the formation of long-lived superheavy elements (SHE) after the end of the r-process. Applying different models for spontaneous fission lifetimes, it was shown, that the formation of SHE depends strongly on areas in the nuclear chart with very short lifetimes. Different nuclear (mass) models lead to a different size of this region, which can suppress strongly the formation of SHE.

III.2 Panov, Korneev, Lutostansky, and Thielemann showed that existing beta-delayed fission probabilities are probably overestimated due to incomplete beta-strength-functions utilized in the calculations. To overcome the problem, the approach based on finite Fermi-systems theory, was applied to beta-strength-functions calculations.

III.3 New models for spontaneous fission rates were worked out during the 3rd year, in addition to the initial plan. New calculations for beta-delayed processes were also performed. Panov and the group from Kurchatov Institute carried out calculations on the basis of mass and fission barrier predictions in the framework of the extended Thomas-Fermi and Strutinsky integral (ETFSI) approach and a beta-strength function model, derived within the framework of the Finite Fermi-system formalism. The probabilities of beta-delayed fission and beta-delayed neutron emission were calculated for a large set of isotopes of interest in r-process calculations.
The new calculations show that previous predictions of probabilities for beta-delayed processes were overestimated significantly in a number of cases. Applications of the new results to r-process calculations are important for the region of nuclei with Z>110 and A>300, for which fission barrier predictions are presently only in the preparation stage.

III.4 Numerical r-process calculations were used as to test spontaneous fission rates predictions. Korneev and Panov considered nucleosynthesis of heavy nuclei in the scenario of NSM, taking into account all possible fission channels – neutron-induced, beta-delayed and spontaneous fission. The nucleosynthesis results were compared for different models of spontaneous fission, including phenomenological models. Some of the models were derived on the basis of the Myers-Swiatecki formula (1957) and new mass predictions.
The influence of different s.f. models on SHE yields was investigated. A strong dependence of SHEs and nuclei-cosmochronometers yields on s.f. models was shown in nucleosynthesis calculations and it was concluded that spontaneous fission plays the most significant role during the beta-decay of the heaviest nuclei back to the superheavy island. The comparison of nuclear predicted cosmochronometer yields with observations shows that one of the models used for s.f. gave excellent results, not only for the heavy nuclei with A from 130 to 196, but also for U and Th isotopes.

III.5 The r-process path in the region of nuclei with N>184 was discussed by Petermann et al. (2012) and will be considered in nearest future when the new data will appear. In part, the extended calculations of $P_{\beta df}$ values for actinide nuclei with known fission and mass predictions were performed and the extension of calculations for $P_{\beta di}$ of superheavy nuclei are in preparation.
Milestones 3a, 3b finished completely, the work on 1ab was extended.

IV. Core collapse supernovae theory, NLTE-effects, and simulations of shock-breakout

IV.1 During the supernova explosion the major part of gravitational binding energy of a star is released in the form of neutrino of different species. Only a small part (of the order of 1%) of this energy goes to the kinetic energy of explosion. Therefore the careful handling of neutrino transport during the collapse and post-bounce phase is of crucial importance for realistic calculations of core-collapse supernova explosions and the accompanying nucleosynthesis.
Yudin and Nadyozhin developed a scheme for calculating neutrino transport processes in collapsing stellar core in the following form. The computing domain is divided into two zones, an opaque and a transparent one. In the opaque zone the Neutrino Heat Conduction (NHC) theory is utilized as developed in Imshennik & Nadyozhin, JETP, 63, (1972) with an additional account for arbitrary scattering processes (coherent and non-coherent) according to Nadyozhin & Yudin, Astron. Lett., 34, 3, (2008). The use of NHC theory ensures exact handling of all neutrino-matter interaction processes and is computationally much easier than the use of ordinary transport solvers.
In the transparent zone the numerical scheme of Nadyozhin & Otroshenko Astron. Lett., 57, (1980)

(hereinafter N&O scheme) is applied, which uses the neutrino fluxes at the edge of the NHC-zone as internal boundary conditions. However, the joint use of these two approaches causes a problem. Some artificial perturbations give rise to an uncontrolled shifting of the zone interfaces. The solution of the problem lies in interpolating all involved quantities (neutrino intensity and opacity) along the computational grid of optical depth rather than radius. The new scheme permits to calculate through the complete collapse and explosion, including the infall phase, bounce and post-bounce with neutrino transport during the entire supernova explosion.
Yudin and Nadyozhin (in collaboration with T.L. Razinkova) also studied the structure of super-dense stars with a phase transition from nuclear to quark matter. Special attention was paid to the appearance of hydrostatic instabilities during the cooling of the star due to the neutrino energy losses. The corresponding paper was accepted for publication in Astronomy Letters (March 2013).

IV.2 As a part of the project the research of NLTE effects in radiation transport has been performed by P.V. Baklanov, M.S. Potashov, and S.I. Blinnikov. Potashov and Blinnikov studied the role of two-photon processes in 2s-1s spectra in the models of supernovae of type IIP (**milestone 7a**).

With accurate opacity tables, reflecting the pre-supernovae abundance composition, a time-dependent solution of the radiative transfer equations, coupled to the equations of hydrodynamics, is obtained with the help of the software package STELLA. The code STELLA assumes the LTE approximation for matter while radiation is fully in non-equilibrium. Thereafter the output is post-processed: a self-consistent solution is obtained for the transport equation in spectral lines in the Sobolev approximation and for a full system of kinetic equations for the populations of discrete levels. In the end, spectra are obtained. This step is performed with the help of a new software package LEVELS.

Utrobin and Chugai (2005, Astronomy Letters, 28, 386) have pointed out the importance of time-dependent kinetics for the explanation of the hydrogen lines (e.g. H_α) at *any time after the explosion of SN1987A*. The importance of time-dependence of number densities later than a *few weeks after the explosion* was found by Dessart & Hilier (2007, MNRAS, 383, 57) for SN1999em with the program CMFGEN. De et al (2010, MNRAS, 401, 2081) found, using the software package PHOENIX, that the kinetics is important only *in the first days after the supernova explosion*. Moreover, they found an influence of the total number of levels in the model hydrogen atom and the importance of taking into account the fine structure for the determination of the recombination time to the main level. For a multi-level hydrogen atom this time is less in the early ages of a supernova life, than in the 2-level model atom. Thus, the conclusions of different research groups are still at odds. This report shows the results of the first step in resolving this controversy related to the account of two-photon decay 2s-1s of the hydrogen.

The work of the above mentioned authors has pointed out the importance of the two-photon decay (hereinafter A2q) of the first excited state of the hydrogen atom 2s-1s, for the explanation of the observed strength of the hydrogen lines in the time-dependent calculations. The role of A2q is already investigated in cosmology. Although the A2q is taken into account in the calculations of the spectra of supernovae, its importance in the theory of supernova has not been dealt with the same detail as in cosmology. De et al. (2010, MNRAS, 407, 658) show, using an example of a simple 4-level hydrogen atom in the PHOENIX model of SN1999em, that accounting for A2q has little effect on the proportion of ionized hydrogen at high optical depths. They find a difference of only 20% for the *external layers* with the continuum optical thickness (at 500 nm) about 10^{-4} .

In our calculation (STELLA + LEVELS) for a model, including a 3-level 1s, 2s, 2p hydrogen in steady-state approximation, the results show the importance of A2q for *intermediate layers* of the star. In the nearest future, the effect of time-dependence will be considered for a multilevel hydrogen atom with account of fine structure. To achieve this goal it is required to evaluate the effect of two-photon decay in both steady-state and time-dependent approximations.

IV.3 Baklanov and Blinnikov have studied the influence of non-LTE processes on supernova light curves (**milestone 7a**).

After a bright burst at shock wave breakout, the supernova ejecta expand rapidly, radiating the energy accumulated during the passage of the shock through the star. An additional source of light can be provided by heating from the decay of $^{56}Ni \rightarrow {}^{56}Co \rightarrow {}^{56}Fe$. Sometimes, as in supernovae of types Ia, Ib/c, or peculiar supernovae II (SN1987A), radioactive decay is the main source of light for several months and years.

To describe the transport of photons and to calculate the luminosity, the code STELLA employs moment approximations to solve the Boltzmann equation for photons. To calculate the absorption coefficients, which are often dominated by numerous spectral lines, an approximation for the expansion opacity is used which depends on the excitation of matter. Those excitations and the equation of state of matter is calculated in the standard STELLA setup in LTE approximation, which may be broken when the ejecta become transparent and the local volume is irradiated by neighboring and distant regions of the expanding supernova envelope. Blinnikov and Baklanov have investigated the conditions for violating LTE in supernova ejecta. The rates of photo and electron impact ionizations have been compared for a number of elements and ions, which play the most important role in the calculation of the opacity in the ejecta. It was concluded that there is a significant dominance of radiative processes over the collisions that allows one to apply the equation of state modified in the nebular approximation (so called Lucy approximation).

It was shown that the new equation of state for ion concentrations shifts the balance towards higher ionization states because the radiation effectively inhibits recombination of ions in the ejecta. The computations of SNIa light curves with the new equation of state demonstrate that at two months after the explosion the U-band flux can be 2 mags higher than in LTE. At longer wavelengths the effect is weaker but still appreciable. In a real supernova another effect may play an important role, namely, fluorescence. In a supernova, this leads to an efficient processing of high-energy photons into less energetic ones. For SN light curves this should lead to transfer of energy from the ultraviolet to the visible and infrared ranges. The work on a consistent treatment of fluorescence in radiation-hydrodynamics computations of supernovae is underway.

All these NLTE effects may be significant for applications of the new method to measure cosmological distances based on supernovae of type IIn as primary distance indicators (Blinnikov S., Potashov M., Baklanov P., Dolgov A., 2012, JETPL, 96, 153; Potashov M., Blinnikov S., Baklanov P., Dolgov A., 2013, MNRAS, 431, L98).

IV.4 Tolstov and Blinnikov have compared the results of the predictions for shock breakout (**milestone 7b**) for three codes: the equilibrium diffusion gray radiation-hydro code SNV, non-equilibrium multigroup radiation-hydro code STELLA and ultrarelativistic non-equilibrium multigroup transfer code RADA (all three codes are discussed and compared by Tolstov, Blinnikov, Nadyozhin, 2013, MNRAS, 429, 3181). The sensitivity of the predictions for the shock emission on the parameters of the numerical scheme, such as the boundaries of the frequency interval (including the X-ray range) and the approximations in the opacity description, have been tested.

It is found that a high-temperature peak behind the shock front and the production of a hard ``tail'' in spectrum are suppressed by extremely low true absorption, with a cross-section at the level 10^{-6} of Thomson scattering in a presupernova of type SN Ib. This level of absorption can be provided by the double Compton effect, thus it must be taken into account in realistic models of radiation-dominated shock waves in a supernova. Some additional refinements necessary in the methods of constructing shock-breakout models are pointed out. Among them have to be considered how the relativistic and geometric effects in radiative transfer in a comoving frame of reference influence the predictions of supernova light curves and spectra at the epoch of shock-breakout. The algorithm for coupling of a fully relativistic hydrodynamic code for large Lorentz factors with the multigroup relativistic radiative transfer code RADA is constructed now and tested by a number of analytic solutions. All planned investigations have been performed.

V. Burning flame front investigation in SNIa explosions

The crucial question in SNe Ia is the question of a flame propagation in a pre-supernova white dwarf. In the semi-degenerate scenario (a white dwarf - red giant binary) an explanation is required how a sub-sonic flame front (deflagration) can change to a super-sonic detonation at densities around 2 10^7 g/cm^3 is required. The problem is complicated by the extreme differences in length scales: the thickness of a flame front is about 10^{-5}-10^{-3} cm (Timmes F. X., Woosley S. E., Ap. J. 396, 649 (1992); Blinnikov S. I., Glazyrin S. I., Dolgov A.D., MNRAS 433, 2840 (2013)), a characteristic length-scale of the transition is comparable with the size of a star ~1000 km. Such conditions are plausible for the growth of many instabilities the front is subject to. These instabilities could accelerate the flame velocity, preparing conditions for the deflagration to detonation transition. It is commonly accepted that this factor is crucial for the solution of the problem.

The main efforts were devoted to the following instabilities:

V.1 Thermo-pulsational instability is a one-dimensional effect in burning systems with strong dependence of burning rate on temperature. The strength of dependence is characterized by the Zeldovich number. When the flame Zeldovich number exceeds the critical value its velocity becomes pulsational and could influence the dynamics of SNIa (Bychkov V. V., Liberman M. A. Astroph. J. 451, 711 (1995))

V.2 The Landau-Darries instability is a multidimensional effect of a thin (compared to perturbation wave-lengths) flame front. On the linear stage every mode is absolutely unstable, but there exists a nonlinear stabilization in cusps (Zeldovich Ya. B. PMTF №1, 102 (1966)). It could develop the fractal structure of the flame surface, therefore increasing its velocity significantly. A good model for this process is absent. For SNe Ia this instability was studied by Röpke F. K., Hillebrandt, W and Niemeyer, J. C. (Astroph. J. 420, 411, 2004) and Bell J. B. et al. (Astroph. J. 606, 1029 (2004))

V.3 The Rayleigh-Taylor instability appears in flows with gravity field, or accelerated flows, with nonzero gradient of density (in fact the effect of gravity on thin-flame stability was considered first by Landau L.D. (ZhETF 14, 240 (1944)), so for flames it would be more correct to call it Rayleigh-Taylor-Landau instability). For SNe this instability plays a role in late stages, when the region of the burned material is comparable to the whole star (Bell J. B. et al. Astroph. J. 608, 883 (2004); Zingale, M. et al. Astroph. J. 632, 1021-1034 (2005)). It leads to extensive turbulization of the burning front and therefore its acceleration.

Glazyrin and Blinnikov investigated the effects of all these instabilities for SNIa with the hydrocode FRONT1D, simulating the flame front structure with adequate physics (compressible hydrodynamics, thermoconductivity, nuclear kinetics and Nadyozhin EOS, that takes into account degeneracy). As a result all flame parameters were obtained from first principles (normal flame velocity, thickness, change of chemistry...). These parameters are close to those obtained by Timmes F. X., Woosley S. E. (Astroph. J. 396, 649 1992).
Also in these one-dimensional studies the question of stability under the thermo-pulsational instability was analyzed. After changing realistic nuclear kinetics to artificial Arrhenius and varying the Zeldovich number, an unstable regime of front propagation was obtained together with the region in parameter space where the instability develops (Blinnikov S. I., Glazyrin S. I. and

Dolgov A.D. MNRAS 433, 2840 (2013)). The results show that in SNIa the flame stability is subject to this instability (contrary to prevous results by Bychkov, Liberman (1995)). This work is an hydrodynamical extension of a toy-model study (Glazyrin, S. I., Sasorov, P. V. MNRAS 416, 2090 (2011)), proposed to study physics of pulsations in a pure way.

For multidimensional simulations the new open-source code FRONT3D was written. For hydrodynamics an approximate Riemann solver HLLC is used together with a high-order approximation WENO5. It allows to describe well smooth subsonic flows together with discontinuities. The use of this approach developed in FRONT1D (simulating front by thermoconductivity with full kinetics) is impossible nowadays when studying processes on scales much bigger than the front thickness (which is required both by Landau and Rayleigh-Taylor-Landau instabilities). To work around this a 2D front-tracking approach with level-set method was implemented. It permits to track the front position when assuming that it is infinitely thin. The algorithm proposed in Smiljanovski V. et al. (Comb. Theory and Modelling 1, 183 (1997)) and Reinecke, M. et al. (Astronomy and Astrophysics 347, 724 (1999)) satisfies conservation laws for the level-set method. This approach needs two input parameters to be set: normal flame velocity and energy release. These parameters were obtained previously with FRONT1D.

The investigation of the Landau-Darries instability was considered with the FRONT3D code. All simulations were performed in a “channel” using two-dimensional rectangular geometry with inflow-outflow boundary conditions in X-direction and periodic boundaries in Y-direction. Initially a plane flame front with harmonic perturbations was set. For both one- and multi-mode perturbations the cusp formed after some time. The resulting increase of the velocity is only 3-4% and cannott explain the deflagration to detonation transition (Glazyrin S.I. Astronomy Letters 39, 221 (2013)).

The effect of external turbulence influence on the flame was studies in a similar manner (a close study was conducted by Ropke F. K., Hillebrandt, W and Niemeyer, J. C. (Astroph. J. 421, 783 (2004))). According to a renormalization group analysis by Yakhot V. (Comb. Sci. and Tech. 60, 191 (1988)), the flame is perturbed by external turbulence, its velocity increases with increasing turbulence intensity according to a simple analytic implicit relation – Yakhot's formula. Such relations are an essential ingredient for turbulence accounting in large-scale supernova simulations. This work was aimed to check Yakhot's formula as a first approximation to the turbulent flame velocity in supernova Ia. We simulated the propagation of an initially plane front in vertical divergence-free flow with a Kolmogorov spectrum. Results show that for low-intensity turbulence flame speeds it is determined by a cusp structure and is independent of turbulent pulsations. For strong turbulent flows (turbulent pulsations are compared with the flame speed) the front is strongly curved which increases the velocity for tens of percent. The result obtained gives qualitative but not quantitative agreement with Yakhot's formula, which needs therefore modifications.

The turbulization of the flow proceeds by two processes: noise of the flame itself and hydrodynamical instabilities. The first process was not yet studied but is planned. The Rayleigh-Taylor-Landau instability generates turbulence by appearance of shear flows. This instability appears on a spatial scale of the whole star, that is why a turbulence model is required. A k-epsilon model of turbulence (Guzhove et al. VANT TPF 3, 37 (2005)) was adopted for problems with flames. The benefits of such types of models lies in the possibility of reproducing correct three-dimensional properties of turbulence in low-dimensional simulations (in our case 1D). With this model the full-star one-dimensional simulations could be considered. The results show that the turbulence develops almost immediately and accelerates the flame to a constant velocity ~300 km/s. The appeared turbulent energy $\sim 10^{15}$ cm^2/s^2 is close to values from more sophisticated simulations (Röpke ApJ (2007)).

The results of the flame study made in this project cover all major instabilities and are the basis for planned full-star simulations of SNIa. Numerical simulations were performed in a supercomputer center at Novosibirsk State University.

VI. Core collapse supernovae, multi-D radiation transport, long-term neutrino wind simulations, nuclear reaction and equation of state input, as well as nucleosynthesis (Basel)

The Basel team consists of the senior members F.-K. Thielemann (nucleosynthesis studies in astrophysical explosions), M. Liebendörfer (core-collapse supernovae), T. Rauscher (nuclear cross sections and nucleosynthesis applications), M. Pignatari (evolution of AGB stars/s-process, SN Ia progenitors, and nucleosynthesis/cosmochemistry connections), who are sub-project leaders for these topics. Additional team members are the postdocs M. Hempel (equation of state at highest densities), R. Caberzon (smooth particle hydrodynamics for a variety of applications, including core collapse with neutrino transport as well as stellar collisions, e.g. for SNe Ia channels), T. Kuroda (general-relativistic radiation hydrodynamics), K.-C. Pan (late behavior of explosions, remnants) and 6 graduate students involved in related projects. It should be mentioned that the research of the team covers the whole range from nuclear reactions and the equation of state, over stellar evolution calculations with the MESA code, related nucleosynthesis studies (especially s-process), 3D core-collapse supernova modeling with neutrino transport (addressing also the transition to hypernovae) and the related explosive nucleosynthesis, including the origin of the r-process in jets of a small subclass of fast-rotating supernovae as well as neutron star mergers, up to the pre-evolution of SNe Ia by studying accreting white dwarfs and their pre-explosive composition and explosive nucleosynthesis of thermonuclear SNe Ia. All these aspects (from funded SNF and ERC research) have entered in the collaboration with our eastern partners.

VI.1 Nuclear reaction rates have been calculated with the aid of the non-Smoker code (Rauscher & Thielemann 2000, and updates, e.g. Rauscher 2011), neutron-induced fission calculations were perfomed extensively (Panov et al. 2010, 2011abc), in a similar way extensions towards beta-delayed and spontaneous fission were investigated (Panov et al. 2013Ab, Petermann et al. 2010, 2012, Langanke et al. 2011, Thielemann et al. 2010, 2011), many neutron-capture reactions (Rauscher jointly with the nToF-collaboration) have been analysed, also charged-particle reactions far from stability were addressed (e.g. Dillmann et al. 2011). Nuclear equation of state developments and tests for core-collapse supernovae have been carried out by Hempel et al. (2011, 2012, 2013) and Fischer et al. (2010c, 2011ab, 2012a). This relates all to **milestone 1**.

VI.2 Extended efforts were undertaken in 1D and multi-D radiation transport, applied to core-collapse supernova calculations (Liebendörfer et al. 2010, Fischer et al. 2010ab, 2012b, Lentz et al. 2012, Pang et al. 2011), the multi-D magneto-hydrodynamics (MHD) code FISH was developed by R. Käppeli (Käppeli et al. 2011), making use of the isotropic diffusion source approximation (ISDSA) for neutrino transport, and succesful applications were performed for core-collapse supernovae with rotation and strong magnetic fields (Winteler et al. 2012, **milestone 2**).

VI.3 Phenomenological tests in r-process, νp-process, and p-process parameter studies of the neutrino wind of core-collapse supernovae have been performed with extended constraints from nuclear physics/reaction input (Farouqi et al. 2010, Arcones (et al.) 2011a-d, Thielemann et al. 2011, Langanke et al. 2011, Arcones & Bertsch 2012) (**milestone 3a**). Attempts to analyze this in realistic models were undertaken by Arcones & Janka (2011), Arcones & Montes (2011), Petermann et al. (2012) and Arcones & Thielemann (2013) (**milestone 3b**).

VI.4 A very general review of the role of massive stars and their supernovae in the chemical evolution of galaxies was presented, pointing out especially the highly uncertain understanding of nuclei between the Fe-group and the A=130 r-process peak (Thielemann et al. 2010, 2011ab, Nishimura et al. 2012) (**milestone 6**).

VI.5 Stellar evolution studies analyzing nuclear input sensitivities (e.g. $^{12}C+^{12}C$) were undertaken (Bennett et al. 2012, Yusof et al. 2013, Pignatari & Herwig 2013, Pignatari et al. 2013Abc). The effect of rotation and resulting primordial ^{14}N and ^{22}Ne, plus the influence on s-process abundances at low metallicities was investigated by (Frischknecht et al. 2010ab, 2012, Hirschi et al. 2012) (**milestone 3b**).

VI.6 The progenitor evolution of type Ia supernovae in order to understand the seed composition of accreted and H/He-burned matter was analyzed by M. Pignatari (in preparation) (**milestone 7b**).

VII. Stellar models, including hydrodynamical processes, impact on stellar properties and nucleosynthesis, consequences for chemical evolution (Geneva)

The Geneva team consists of the senior members and sub-project leaders C. Charbonnel (low- and intermediate-mass stars) and G. Meynet (massive stars). Additional team members are/have been S. Ekström (low-metallicity massive stars), T. Decessin (rotating stars), P. Eggenberger (low mass stars), W. Chantereau (low-mass stars), and N. Lagarde (stellar mixing due to instabilities). They use the so-called GENEVA CODE as well as the code STAREVOL to compute models of stars over a wide range of masses and metallicities. These aspects are partially funded by SNF grants. Custom-made stellar evolution models for the present proposal have been computed with the stellar evolution code STAREVOL that already includes a description of all processes for the transport of chemicals and angular momentum.

VII.1 We studies the impact of rotation, diffusion, gravity waves, magnetic fields, and thermohaline instability on the stellar structure and evolution for stars over a large domain in both stellar mass and metallicity (Decressin et al. 2010, Charbonnel & Lagarde 2010, Aurière et al. 2011, Lagarde et al. 2011, 2012ab, Ekström et al. 2012, Maeder & Meynet 2012, Konstantinova-Antova 2012, Mowlavi et al. 2012, Maeder et al. 2013, Georgy et al. 2013). The latter provides grids of models including these non-standard processes and the various predictions are tested using different constraints (surface abundances, asteroseismology, chemical evolution) for stars of various masses at different evolutionary stages (**milestones 3b, 6**).

VII.2 The resulting effect of massive low metallicity stars with rotation on the chemical evolution of galaxies was extensively analyzed by Chiappini et al. (2011), Lagarde et al. (2012b), Cescutti et al. (2013) (**milestone 3b, 6**). The predictions for the yields of light elements of our new stellar models including rotation-induced mixing and thermohaline instability were also tested againts Galactic evolution. In particular, the resulting evolution of the light elements D, He and He was compared with their primordial values inferred from the Wilkinson Microwave Anisotropy Probe data and with the abundances derived from observations of different Galactic regions. We showed that Galactic chemical evolution models computed with stellar yields including thermohaline mixing and rotation fit better observations of ^{3}He and ^{4}He in the Galaxy than models computed with standard stellar yields. In particular the inclusion of thermohaline mixing in stellar models provides a solution to the long-standing "^{3}He problem" on a Galactic scale. Stellar models including rotation-induced mixing and thermohaline instability reproduce also the observations of D and ^{4}He. (Lagarde et al. 2011, 2012ab).

VII.3 We investigated the chemical and dynamical evolution of globular clusters and the impact on the halo stellar population. We examine various implications from a dynamical and chemical model of globular clusters, which successfully reproduces the observed abundance patterns and the multiple populations of stars in these systems assuming chemical enrichment from fast rotating massive stars (Charbonnel 2010, Krause et al. 2012, 2013). Typically, we find that the initial masses of globular clusters must be ~8-10 times (or up to 25 times, if second generation stars also escape from globular clusters) larger than the present-day stellar mass. The present-day Galactic

globular clusters population must then have contributed to approximately 5-8% (10-20%) of the low-mass stars in the Galactic halo. We also show that the detection of second generation stars in the Galactic halo, recently announced by different groups, provides a new constraint on the GC initial mass function. These observations appear to rule out a power-law GCIMF, whereas they are compatible with a log-normal one (Charbonnel & Montmerle 2011). Finally, the high initial masses also imply that globular clusters must have emitted a large amount of ionising photons in the early Universe.
Our results reopen the question on the initial mass function of globular clusters, and reinforce earlier conclusions that old globular clusters could have represented a significant contribution to reionise the inter-galactic medium at high redshift (Schaerer & Charbonnel 2011). These theoretical studies are complemented by observational works with VLT that help tracing the evolution of globular clusters through the chemical composition of their stellar populations (Lind, Charbonnel et al. 2011)(**milestone 6**).

Highlights of the Collaboration:

During the years 2010-2013 Russian/Ukranian members visited their western counterparts and/or attended workshops/conferences in the West in even years, while joint workshops were organized in Russia/Ukraine in odd years.
In 2010 a large portion of the eastern Scopes partners attended the Nuclei in the Cosmos Conference in Heidelberg. In addition, the “Nuclear Astrophysics” workshop as well as the “Chemical Enrichment of the Milky Way” workshop at the Rinberg Castle (Tegernsee) served as points of exchange and joint work in 2010. In 2012 this role was played again by the “Nuclear Astrophysics” workshop at the Ringberg Castle and the “Russbach School” in Austria. 2011 and 2013 were the years with joint collaboration workshops in Odessa and Moscow.

In 2011:
(1) About 30 scientists from the Ukraine, Russia, Switzerland, and Germany attended the Workshop in Odessa on ”Heavy elements in galactic chemical evolution and NLTE effects”. In the framework of the workshop, after two days of exchange, a round table with SNF-grant participants and scientists from all participating institutions was held. In an extended discussion with the Ukrainian/Russian project leaders (Lyudmila Mashonkina, Tamara Mishenina, Igor Panov) the visitors from Switzerland/Germany (Almudena Arcones, Sylvia Ekström, Tobias Fischer, Karl-Ludwig Kratz, Marco Pignatari and Friedrich-Karl Thielemann) pointed out the work progress and emphasized (for future activities) the importance of the discussion, in which all the project members took part. It was noted that on the way to developing more realistic, physical scenarions of stellar evolution, nucleosynthesis and SN explosions, progress was visible in all related aspects - observations, interpretation of chemical evolution data, nucleosynthesis predictions in stellar winds and explosions, as well as hydrodynamics, magnetohydrodynamics, and radiation/neutrino transport in astrophysical simulations of supernovae.
(2) In Moscow in a shorter workshop addressed the following questions: further r-process calculations with different spontaneous fission rates (Korneev), results of preliminary calculations of supernova spectra, taking into account time-dependent NLTE processes for multiply charged ions in the Sobolev approximation (Potashov), problems in numerical simulations of multigroup relativistic transfer for supernova shock breakout (Tolstov), possibility of neutrino nucleosynthesis in helium and carbon shells of core-collapse supernovae (Nadyozhin), and the excluded volume approximation for the equation of state of supernova matter (Yudin).

In 2013:
(3) About 25 scientists from the Ukraine, Russia, Switzerland, Great Britain attended the Workshop

“Heavy element nucleosynthesis and galactic chemical evolution” in Moscow (September 2013), where the main results obtained during the years 2012-2013 were discussed attended by the following Swiss/UK members of the Scopes project: M. Hempel, M. Pignatari, T. Rauscher, and F.-K. Thielemann. Similar to the 2011 meeting, an open discussion about future ambitious aims and problems was held, which actually laid the groundwork for the new proposal to continue our joint work under the SCOPES program for 2014-2016.

All events, their programs and presentation slides can be found on the website:
http://dau.itep.ru/sn/collaboration

The overall activities of all participants of this Scopes project were in full accordance with the initial proposal, in fact they exceeded what was planned initially for the Russian and Ukranian teams. The number of collaborative meetings was higher than expected. In 2010, due to additional opportunities and support, two rather than one Russian scientists visited Switzerland. Ukrainian and Russian scientists attended eight scientific conferences instead of two which were planned originally. In 2011 Ukrainian and Russian scientists attended 11 scientific conferences instead of 6 which which were planned originally. The activity grew every year. In 2012/2013 36 eastern participants gave talks at 14 different conferences.

While not giving here all the details, we would like to summarize that the western as well as eastern partners of this Scopes projects gave in total typically about 60-65 talks at international scientific workshops/conferences per year. On average this breaks down to about 28 talks by the eastern partners and 36 by the western partners. This is, in our eyes, a strong proof for the international recognition and scientific quality of the research performed by all partners.

While a detailed list of publications will be given further down, a huge amount of work went into establishing the following databases

Web pages prepared by grant members:

http://dau.itep.ru/sn/lctheory - Tools for Supernova Light Curve Catalogue
http://dau.itep.ru/sn/snviewobs - The Catalogue of the Supernova Light Curves
http://dau.itep.ru/sn/snview - The Catalogue of the Supernova explosion models
http://dau.itep.ru/sn/snatomicdata - The list of atomic lines with wavelengths in the range from 0.1 to 100 000 A

Awards:

1st rang among theoretical publications within RRC ITEP in 2012 for Korneev and Panov
Lise Meitner Prize of the European Physical Society in 2012 for Friedrich-K. Thielemann
ERC advanced grant in 2013 for Friedrich-K. Thielemann

2.2 Is the co-operation progressing satisfactorily according to expectations with regard to collaboration?

As seen from the details given above, it can be recognized that all groups are very active in their related and overlapping research fields from nuclear input over stellar (evolution and explosion) modeling and abundance observations in (old) stars, to their interpretation in chemical evolution of galaxies. Also, quite a number of joint investigations of at least two of the participating groups have taken place or are still in progress.
Seven meetings where members of the Swiss groups and the groups from Eastern Europe could jointly attend, have increased the overlap and joint planning strongly. In the list of publications

given at the end of the report, one can recognize that a true collaboration has started. *Over the six years of two subsequent Scopes projects in total 30 joint publications emerged*, which include members of more than one of the participating research groups. The large number of additional publications of our Eastern European Partners with collaborators from the West, underline clearly that our partners have an international standing, going beyond the collaboration with the Swiss groups.

2.3 Please list the involved individuals:

2.3 Please list the involved individuals.

Name	Country	Age	Sex	Remarks
Andrievsky Sergei	Ukraine	51	M	Prof
Chekhonadskhih Fedor	Ukraine	29	M	PhD
Korotin Sergei	Ukraine	52	M	PhD
Mishenina Tamara	Ukraine	63	F	Prof
Yushchenko Vladimir	Ukraine	27	M	PhD student
Baklanov Petr	Russia	34	M	PhD student
Blinnikov Sergey	Russia	65	M	Prof
Glazyrin Semen	Russia	27	M	PhD student
Korneev Ivan	Russia	30	M	PhD student
Mashonkina Lyudmila	Russia	61	F	Prof
Nadyozhin Dmitriy	Russia	76	M	Prof
Panov Igor	Russia	62	M	PhD
Potashov Marat (instead of Tolstov)	Russia	30	M	PhD student
Tolstov Aleksei	Russia	35	M	PhD
Velichko Anna	Russia	28	F	PhD student
Yudin Andrey	Russia	35	M	PhD
Corinne Charbonnel	Switzerland	48	F	Prof.
Daniel Schaerer	Switzerland	49	M	Prof.
Cristina Chiappini	Switzerland	45	F	Prof. - now in Potsdam
Nadege Lagarde	Switzerland	31	F	PhD student
Georges Meynet	Switzerland	55	M	Prof.
Sylvia Eckström	Switzerland	47	F	Postdoc
Cyril Georgy	Switzerland	31	M	PhD student
Friedrich-K. Thielemann	Switzerland	62	M	Prof.
Matthias Liebendörfer	Switzerland	48	M	Prof.
Thomas Rauscher	Switzerland	48	M	Lecturer
Marco Pignatari	Switzerland		M	Ambizione Fellow
Almudena Arcones	Switzerland	35	F	Postdoc until 2012
Matthias Hempel	Switzerland		M	Postdoc
Urs Frischknecht	Switzerland	34	M	PhD student – finished 2012
Roger Käppeli	Switzerland	31	M	PhD student – finished 2012
Albino Perego	Switzerland	31	M	PhD student – finished 2012
Christian Winteler	Switzerland	32	M	PhD student – finished 2012
Marius Eichler	Switzerland		M	PhD student
Kevin Ebinger	Switzerland		M	PhD student
Umberto Battino	Switzerland		M	PhD student
Sofie Fehlmann	Switzerland		F	PhD student

3. Practical issues

3.1 Did you encounter any major problems (e.g. telecommunication, transfer of goods, taxation, customs)? If yes, please specify the problems and describe how you solved them.

No

3.2 How did you transfer the funds to the project partners in Eastern Europe?

The Russian team leader opened a special EURO-account at Moscow citi-bank for the transfers from SNSF. The money, according to the rules of SNSF (Guidelines for the Administration of Grants for Joint Research Projects, item 4.), was sent by 2 installments to the account, used in previous years. (SCOPES program 2005-2008, grant No. IB7320-110996). Since 2011, in connection with delayed transfer via Moscow citi-bank, the Russian team used CHF-account at UBS Bank, Basel.
The Ukrainian team leader opened a special CHF-account at UKRSIBBANK bank in Odessa for the transfer from SNSF. The money, according to the rules of SNSF (Guidelines for the Administration of Grants for Joint Research Projects, item 4.) were sent by 3 installment to the account.

3.3 Are there important developments/changes in the scientific landscape of the involved partner countries?

Postgraduate student Sitnova (Institute of Astronomy) appears instead of Velichko leaving to pregnancy vacation. Postgraduate student Potashov Marat (ITEP) appears at last stage instead of Tolstov, leaving to JAERI (Japan)
Chekhonadskih finished his PhD thesis and became Dr of science.
In Switzerland four PhD students finished and a new team of four started.

4. Annexes

Include any documents (publications, proceedings, etc.) which you consider to be of relevance.

Bibliography

This section serves in a combined way as bibliography, listing published articles by the Scopes partners relevant to the subject of research and within the previous support periods 2006-2009 and 2010-2013 (for our Eastern partners in italic). Bold fonts indicate joint publications by several SCOPES partners (two more publications with the Ukrainian partners are in the making, one on Mn with Basel and one on Li with Geneva). This bibliography should indicate that (a) all partners within this Scopes project are performing at an internationally leading level, and (b) this background provided the stimulus and motivation to publish in total 30 joint papers between two or more of the four Scopes partners (with Odessa only entering in the (this) second Scopes program 2010-2013). We think that this is a quite successful result.

Andrievsky S. M., Spite M., Korotin S. A., et al., A&A, 494 (2009), 1083

Andrievsky S., Spite M., Korotin S., Spite F., Bonifacio P., Cayrel R., Francois P., Hill V., NLTE strontium abundances in extremely metal poor halo stars, PoS(NIC XI)94, 11th International Symposium on Nuclei in the Cosmos 2010, Heidelberg, Germany

Andrievsky S. M., Spite F., Korotin S. A., Francois P., Spite M., Bonifacio P., Cayrel R., Hill V., NLTE strontium abundance in a sample of extremely metal poor stars and the Sr/Ba ratio in the early Galaxy, A&A 530 (2011), A105

Andrievsky S.M., Lépine J.R., Korotin S.A., Luck R.E., Kovtyukh V.V., Maciel W.J., Barium abundances in Cepheids, Mon. Not. Roy. Astron. Soc. 428 (2013), 3252

Arcones, A., Janka, H.-T., Nucleosynthesis-relevant conditions in neutrino-driven supernova outflows. II. The reverse shock in two-dimensional simulations, A & A 526 (2011), A160

Arcones A., Explosive nucleosynthesis: nuclear physics impact using neutrino-driven wind simulations, PoS, PoS NIC XI (2010) 082

Arcones A., Montes F., Production of Light Element Primary Process nuclei in neutrino-driven winds, Proceedings of the Hamburg Neutrinos from Supernova Explosion (HAvSE 2011) July 19-23, 2011, Hamburg, Germany

Arcones, A., Montes, F., Production of Light Element Primary Process nuclei in neutrino-driven winds, Ap. J., 731 (2011), 5

Arcones, A., Martinez-Pinedo, G., Dynamical r-process studies within the neutrino-driven wind scenario and its sensitivity to the nuclear physics input, Phys. Rev. C , 83 (2011), 045809

Arcones, A., Bertsch, G.F., Nuclear correlations and the r-process, Phys. Rev. Lett. 108 (2012), 151101

Arcones, A., Thielemann, F.-K., Neutrino-driven Wind Simulations and Nucleosynthesis of Heavy Elements, J. Phys. G, 40 (2013), 013201

Argast D., Samland M., Thielemann F.-K., Qian Y.-Z., Neutron star mergers versus core-collapse supernovae as dominant r-process sites in the early Galaxy, A & A 416 (2004), 997

Aurière, M., Konstantinova-Antova, R., Petit, P., Charbonnel, C. et al., A dominant magnetic dipole for the evolved Ap star candidate EK Eridani, A&A 534 (2011), A139

Bad'in D. A., Blinnikov S. I., Postnov K. A., Heating of the Circumstellar Medium by Gamma-Ray Burst Prompt Emission, Astron. Lett. 36 (2010), 687

Basak N.Yu., Mishenina T.V. Lines selection to determine the chemical composition of stars in the range -3 ≤ [Fe/H] ≤ -0.7, Odessa Astron. Publ. 25 (2012), 159

Belloni, F., Milazzo, P.M., Calviani, M., ..Dillmann, I., .. Leeb, H., .. Rauscher, T. et al.: Neutron-induced fission cross section measurement of ^{233}U, ^{241}Am and ^{243}Am, Physica Scripta T 150 (2012), 014005

Bennett, M.E. , Hirschi, R., Pignatari, M. et al: The effect of ^{12}C +^{12}C rate uncertainties on the evolution and nucleosynthesis of massive stars, MNRAS 420, 3047 (2012)

Best, A., Beard, M., Görres, J., Couder, M., deBoer, R., Falahat, S., Güray, R.T., Kontos, A., Kratz, K.-L., LeBlanc, P.J., Li, Q., O'Brian, S., Özkan, N., Pignatari, M., Sonnabend, K., Talwar, R., Tan, W., Uberseder, E., Wiescher, M.: Measurement of the reaction $^{17}O(\alpha,n)^{20}Ne$ and its impact on the s process in massive stars, Phys. Rev. C 87 (2013), 045805

Blinnikov S.I., Panov I.V., Rudzsky M.A., Sumiyoshi K., The equation of state and composition of hot, dense matter in core-collapse supernovae, A &A 535 (2011), A37

Blinnikov S.I., Tolstov A.G., Multigroup radiative transfer in supernova shock breakout models. Astron. Lett. 37 (2011), 194

Blinnikov S., Tolstov A., Sorokina E., Dolgov A., Radiation hydrodynamics of supernova shock breakouts, High Energy Density Physics 9 (2013), 17
Britavskiy N.E., Andrievsky S.M., Tsymbal V.V., Korotin S.A., Martin P., Andrievska A.S., Chemical composition of semi-regular variable giants. III., A & A 542 (2012), A104
Cabezon R., Garcia-Senz D., Cabezon R.M., Arcones A., Relano A., Thielemann F.-K. ArXiv: 1309.6884 (2013)
Caffau E., Bonifacio P., Francois P., Spite M., Spite F., Zaggia S., Ludwig H.-G., Steffen M., Mashonkina L., Monaco L., Sbordone L., Molaro P., Cayrel R., Plez B., Hill V., Hammer F., Randich S., A primordial star in the heart of the Lion, A &A 542 (2012), A51
Calviani, M., Meaze, M. H., Colonna, N., ..Dillmann, I., Heil, M., .. Rauscher, T. et al.: Neutron-induced fission cross section of 245 Cm: New results from data taken at the time-of-flight facility nTOF, Phys. Rev. C 85 (2012), 3003461
Cescutti G., Chiappini, C. Hirschi R., Meynet G., Frischknecht U., A & A 553 (2013), A51
Charbonnel C., Lagarde N., Thermohaline instability and rotation-induced mixing. I. Low- and intermediate-mass solar metallicity stars up to the end of the AGB, A&A 522 (2010), 10
Charbonnel C., Globular cluster abundances: the imprint of first-generation massive stars, IAU Symposium 266 (2010), 131 (2010)
Charbonnel, C., Montmerle, T., Star Formation in the Local Universe – EES 2010, EAS Publications Series 51 (2011)
Chekhonadskikh F.A., Abundances and absolute stellar magnitudes for F and G supergiants of Magellanic Clouds, Kinem. Phys. Celest. Bodies 28 (2012), 128
Chiappini C., Hirschi R., Meynet G., Ekström S., Maeder A., Matteucci F., A & A 449 (2006), L27
Chiappini C., Ekström S., Meynet G., Hirschi R., Maeder A., Charbonnel C., A & A 479 (2008), L9
Chiappini C., Frischknecht U., Meynet G., Hirschi R., Barbuy B., Pignatari M., Decressin T., Maeder A., Nature 472 (2011), 454
Cowan J.J., Thielemann F.-K., Physics Today, 57 (2004), 47
Cowan J.J., Thielemann F.-K., Truran J.W., Phys. Rep. 208 (1991), 267
Cyburt R.H., Amthor A.M., Ferguson R., Meisel Z., Smith K., Warren S., Heger A. Hoffman R.D., Rauscher T., Sakharuk A., Schatz H., Thielemann F.-K., Wiescher M., Ap. J. Suppl. 189 (2010), 240
Dasgupta B. Fischer T., Horiuchi S., Liebendörfer M., Mirizzi A., Sagert I., Schaffner Bielich J., Detecting the QCD phase transition in the next Galactic supernova neutrino burst, Phys. Rev. D 81 (2010), 103005
Decressin T., Baumgardt H., Charbonnel C., Kroupa P., Evolution of two stellar populations in globular clusters. II. Effects of primordial gas expulsion, A & A 516 (2010), A73
Decressin T., Meynet G., Charbonnel C., Helium-rich stars in globular clusters: constraints for self-enrichment by massive stars, IAU Symposium 268 (2010), 135
Decressin, T., Meynet, G., Charbonnel, C., Prantzos, N., Ekström, S., Fast rotating massive stars and the origin of the abundance patterns in galactic globular clusters, A & A 464 (2007), 1029
Dillmann I., Domingo-Pardo C., Heil M., Käppeler F., Walter S., Dababneh S., Rauscher T., Thielemann F.-K., Comprehensive study of stellar (n,γ) cross sections of p-process isotopes, Part 1: ^{102}Pd, ^{120}Te, ^{130,132}Ba, ^{156}Dy, Phys. Rev. C 81(2010), 015801
Dillmann, I., Coquard, L., Domingo-Pardo, C., .., Rauscher, T., Thielemann, F.-K.: Cross sections for proton-induced reactions on Pd isotopes at energies relevant for the γ-process, Phys. Rev. C 84 (2011), 015802
Dobrovolskas V., Kučinskas A., Andrievsky S.M., Korotin S. A., Mishenina T.V., Bonifacio P., Ludwig H.-G., Caffau E., Barium abundance in red giants of NGC 6752. Non-local thermodynamic equilibrium and three-dimensional effects, A & A 540 (2012), A128
D'Orazi V. , Biazzo K., Desidera S., Covino E., Andrievsky S. M., Gratton R. G., MNRAS 423 (2012), 2789
D'Orazi, V., Campbell, S. W., Lugaro, M., Lattanzio, J. C., Pignatari, M., Carretta, E.: On the internal pollution mechanisms in the globular cluster NGC 6121 (M4): heavy-element abundances and AGB models, MNRAS 433 (2013), 366
Dressler, R., Ayranov, M., Bemmerer, D., Bunka, M., Dai, Y., Lederer, C., Fallis, J., StJ Murphy, A., Pignatari, M., Schumann, D., Stora, T., Stowasser, T., Thielemann, F.-K., Woods, P.J.: ^{44}Ti, ^{26}Al and ^{53}Mn samples for nuclear astrophysics: the needs, the possibilities and the sources, J. of Phys. G 39 (2012), 105201
Ekström, S., Georgy, C., Eggenberger, P., Meynet, G., Mowlavi, N., Wyttenbach, A., Granada, A., Decressin, T., Hirschi, R., Frischknecht, U., Charbonnel, C., Maeder, A.: Grids of stellar models with rotation. I. Models from 0.8 to 120 Msun at solar metallicity (Z = 0.014), A&A 537 (2012), A146

Eggenberger P., Meynet G., Maeder A., Hirschi R., Charbonnel C., Talon S., Ekström S., The Geneva stellar evolution code, Ap. J. Suppl. 316 (2008), 43

Eichler M., Arcones A., Käppeli R., Korobkin O. , Liebendörfer M. , Martinez-Pinedo G., Panov I.V., Rauscher T. , Rosswog S. , Thielemann F.-K., Winteler C., The Impact of Fission on r-Process Calculations, J. of Phys. Conf. Ser. (2013), in press

Farouqi K., Kratz K.-L., Mashonkina L.I., Pfeiffer B., Cowan J.J., Thielemann F.-K., Truran J.W., Nucleosynthesis Modes in the High-Entropy-Wind of Type II Supernovae: Comparison of Calculations with Halo-Star Observations, Ap. J. 694 (2009), L49

Fischer T., Whitehouse S.C., Mezzacappa A., Thielemann F.-K., Liebendörfer M., Protoneutron star evolution and the neutrino driven wind in general relativistic neutrino radiation hydrodynamics simulations, A & A 517 (2010), A80

Fischer T., Thielemann F.-K., Liebendörfer M., Explosions of massive stars and the neutrino-driven wind in simulations using Boltzmann neutrino transport, in Origin of Matter and Evolution of Galaxies: OMEG-2010, AIP Conf. Ser. 1269 (2010), 181

Fischer T., Sagert I., Hempel M., Pagliara G., Schaffner-Bielich J., Liebendörfer M., Signals of the QCD phase transition in core collapse supernovae – microphysical input and implications on the supernova dynamics, Class. Quant. Grav. 27 (2010), 114102

Fischer, T., Sagert, I., Pagliara, G., Hempel, M., Schaffner-Bielich, J., Rauscher, T., Thielemann, F.-K., Käppeli, R., Martinez-Pinedo, G., Liebendörfer, M.: Core-collapse Supernova Explosions Triggered by a Quark-Hadron Phase Transition During the Early Post-bounce Phase, Ap. J. Suppl. 194 (2011), 39

Fischer T., Sagert I., Hempel M., Pagliara G., Schaffner-Bielich J., Mezzacappa A., Thielemann F.-K., Liebendörfer M., Exploring the QCD phase transition in core collapse supernova simulations in spherical symmetry, arXiv:1005.4479, in Proc. of Compact stars in the QCD phase diagram II (CSQCD II)

Fischer, T., Blaschke, D., Hempel, M., Klähn, T., Lastowiecki, R., Liebendörfer, M. et al.: Core collapse supernovae in the QCD phase diagram, Physics of Atomic Nuclei 75 (2012), 613

Fischer, T., Martinez-Pinedo, G., Hempel, M., Liebendörfer, M.: Neutrino spectra evolution during proto-neutron star deleptonization, Phys. Rev. D 85 (2012), 083003

Francois P., Matteucci F., Cayrel R., Spite M., Spite F., Chiappini C., A & A 421 (2004), 613

Freiburghaus C., Rosswog S., Thielemann F.-K., Ap. J. Lett., 525 (1999), L121

Frischknecht U., Hirschi R., Meynet G., Ekström S., Georgy C., Rauscher T., Winteler C., Thielemann F.-K., Constraints on rotational mixing from surface evolution of light elements in massive stars, A & A 522 (2010), A39

Frischknecht U., Hirschi R., Meynet G., Ekström S., Georgy C., Rauscher T., Winteler C., Thielemann F.-K., Boron depletion in 9 to 15 $M_{\odot}$ stars with rotation, in Light Elements in the Universe, IAU Symposium 268 (2010), 421

Frischknecht U., Hirschi R., Thielemann F.-K., Non-standard s-process in low metallicity massive rotating stars,A & A 538 (2012), L2

Fujii K., Rauscher T. et al., Neutron physics of the Re/Os clock. III. Resonance analyses and stellar (n,γ) cross sections of 186,187,188Os, Phys. Rev. 82 (2010), 015804

Garcia-Senz, D., Cabezon, R.M., Arcones, A., Relano, A., Thielemann, F.-K.: High-resolution simulations of the head-on collision of white dwarfs, MNRAS 436 (2013), 3413

Gaponov Yu.V. Lutostansky Yu.S., Giant Gamow-Teller Resonance in Neutron-Rich Nuclei. Phys. of Atom. Nuclei, 73 (2010), 1360

Georgy C., Ekström S., Eggenberger P., Meynet G., Haemmerlé L., Maeder A., Granada A., Groh J.H., Hirschi R., Mowlawi N., Yusof N., Charbonnel C., Decressin T., Barblan F., A & A 558 (2013), A103

Glazyrin, S. and Blinnikov, S. Properties of nuclear flame in presupernova white dwarf, PoS, 11th Symposium on Nuclei in the Cosmos (NIC XI) Heidelberg, 19-23 July 2010, arXiv:1010.5195

Glazyrin S.I., Sasorov P.V., Simple model of propagating flame pulsations, MNRAS 416 (2011), 2090

Glazyrin S.I., Study of burning in supernovae Ia, Astron. Lett. 39 (2013), 221

Glazyrin S., Blinnikov S., Dolgov A., Flame fronts in Type Ia supernovae and their pulsational stability, MNRAS 433 (2013), 2840

Gopka V.F., Yushchenko A.V., Yushchenko V.A., Panov I.V., Kim Ch., Identification of absorption lines of short half-life actinides in the spectrum of Przybylski's star (HD 101065), Kinematics and Physics of Celestial Bodies 24 (2008), 89

Gopka V.F., Shavrina A.V., Vasilyeva S.V., Yushchenko A.V., Andrievsky S.M., Yushchenko V.A.. Preliminary study of red supergiant rm_1-667 in the Large Magellanic, Odessa Astron. Publ. 25 (2012), 9

Gopka V.F., Shavrina A.V., Yushchenko A.V., Yushchenko V.A., *The nature of magnetic chemically peculiar stars phenomenon and the origin of lithium, Odessa Astron. Publ., 25 (2012), 64*
Gorbaneva T.I., MisheninaT.V., Soubiran C., Europium abundances in cool dwarf stars of the galactic thick and thin disks, Kinem. Phys. Celest. Bodies 28 (2012), 121
Gruyters P., Korn A. J., Richard O., Grundahl F., Collet R., Mashonkina L., Osorio Y., and Barklem P. S. Atomic Diffusion and Mixing in Old Stars IV: Weak Abundance Trends in the Globular Cluster NGC6752, A & A 555 (2013), A31
Guerrero, C., Cano-Ott, D., Mendoza, E., .. Dillmann, I., .. Leeb, H., .. Rauscher, T. et al.: Measurement and resonance analysis of the ^{237}Np neutron capture cross section, Phys. Rev. C 85 (2012), 044616
Guerrero, C., Berthoumieux, E., Cano-Ott, D., ..Dillmann, I., Heil, M., Rauscher, T. et al.: Simultaneous measurement of neutron-induced capture and fission reactions at CERN, European Physical Journal A 48 (2012), 29
Gunsing, F., Berthoumieux, E., Aerts, G., ..Dillman, I.,.. Rauscher, T.; Reifarth, R..et al.: Measurement of resolved resonances of 232 Th(n, γ) at the nTOF facility at CERN, Phys. Rev. C 85 (2012), 064601
Gunsing, F., Berthoumieux, E., Aerts, G., ..Dillman, I.,.. Rauscher, T.; Reifarth, R..et al.: Measurement of resolved resonances of 232 Th(n, γ) at the nTOF facility at CERN, Phys. Rev. C 86 (2012), 019902
Gyürky G., Elekes Z., Farkas J., Fülöp Z., Halsz Z., Kiss G.G., Somorjai E., Szücs T., Güray R.T., Özkan N., Yalcin C., Rauscher T.: Alpha-induced reaction cross section measurements on ^{151}Eu for the astrophysical gamma-process. J. Phys. G 37, 115201 (2010)
Gyürky G., Rauscher T., Alpha-induced reaction cross section measurements on ^{151}Eu for the astrophysical γ-process, J. Phys. G 37 (2010), 115201
Halász, Z., Gyürky, G., Farkas, J., Fülöp, Z., Szücs, T., Somorjai, E., Rauscher, T.: Investigation of alpha-induced reactions on ^{130}Ba and ^{132}Ba and their importance for the synthesis of heavy p nuclei, Phys. Rev. C 85 (2012), 025804
Hempel M., Dexheimer V., Schramm S., Iosilevskiy I., Phys. Rev. C 88 (2013), 014906
Hempel M., Fischer T., Schaffner-Bielich J., Liebendörfer M., Ap. J. 748 (2012), 70
Hempel, M., Schaffner-Bielich, J., Typel, S., Röpke, G., Light clusters in nuclear matter: Excluded volume versus quantum many-body approaches, Phys. Rev. C 84 (2011), 055804
Hirschi R., Very low-metallicity massive stars: Pre-SN evolution models and primary nitrogen production, A & A 461 (2007), 571
Hirschi R., Maeder A., Meynet G., Chiappini C., Ekström S., Evolution of the First Stellar Generations, EAS Publ. Ser. 24 (2007), 263
Hirschi, R., Frischknecht, U., Thielemann, F.-K.: Chemical signature of GRB progenitors at low metallicities, Memorie della Societa Astronomica Italiana Supplementi 21 (2012), 28
Hoffman R.D., Rauscher T. et al., Reaction Rate Sensitivity of 44Ti Production in Massive Stars and Implications of a Thick Target Yield Measurement of ^{40}Ca(α,γ)^{44}Ti, Ap. J. 715 (2010), 1383
Käppeli, R., Whitehouse, S. C., Scheidegger, S., Pen, U.-L., Liebendörfer, M.: FISH, A Three-dimensional Parallel Magnetohydrodynamics Code for Astrophysical Applications, Ap. J. Suppl. 195 (2011), 20
Kang Y.-W., Yushchenko A., Hong K., Kim S., Yushchenko V., Chemical Composition of the Components of Eclipsing Binary Star ZZ Bootis, Astron. J., 144 (2012), 35
Katsova, M.M., Livshits, M.A., Mishenina, T.V., The main factors determining the character of the solar-type activity, Geomagnetism and Aeronomy, 53 (2013), 937
Katsova, M.M., Livshits, M.A., Mishenina, T.~V., The character of solar-type activity and the depth of the convective zone, Astronomy Reports, 57 (2013), 702
Kiss G.G., Rauscher T., Szücs T., Kertèsz Z., Fülöp Z., Gyürky G., Fröhlich C., Farkas J., Elekes Z., Somorjai E.: Determining reaction cross sections via characteristic X-ray detection: Alpha-induced reactions on ^{169}Tm for the astrophysical gamma-process, Phys. Lett. B 695 (2011), 419
Kiss G.G. , Szücs T., Gyürky Gy., Fülöp Zs., Farkas J., Kertèsz Z., Somorjai E., Laubenstein M., Fröhlich C., Rauscher T.: Activation method combined with characteristic X-ray counting: A possibility to measure (alpha, gamma) cross sections, Nucl. Phys. A 867 (2011), 52
Kiss, G.G., Szücs, T., Török, Z., Korkulu, Z., Gyürky, G., Halász, Z., Fülöp, Z., Somorjai, E., Rauscher, T.: Investigation of alpha-induced reactions on ^{127}I for the astrophysical gamma process. Phys. Rev. C 86 (2012), 35801
Kiss, G. G., Szücs, T., Török, Z., Korkulu, Z., Gyyürky, G., Halasz, Z., Fülöp, Z., ..Rauscher, T.: Investigation of alpha-induced reactions on ^{127}I for the astrophysical gamma-process, Phys. Rev. C 86 (2012), 049904

Kiss, G.G., Mohr, P., Fülöp, Z., Rauscher, T., Gyürky, G., Szücs, T., Halász, Z., Somorjai, E., Ornelas, A., Yalçın, C., Güray, R.T., Ozkan, N.: High precision $^{113}In(\alpha,\alpha)^{113}In$ elastic scattering at energies near the Coulomb barrier for the astrophysical γ process, Phys. Rev. C 88 (2013), 045804

Klochkova V., Mishenina T., Korotin S., Marsakov V., Panchuk V., Tavolganskaya N., Usenko I., Spectroscopy of high proper motion stars in the ground-based UV, Astrophys. Space Sciences 335 (2011),141

Klochkova V.G., Mishenina T. V., Panchuk V. E., Korotin S.A.; Marsakov V.A.; Usenko I. A., Tsymbal, V.V., Chemical composition of high proper-motion stars based on short-wavelength optical spectra, Astrophys. Bull. 66 (2011) 28-464

Konstantinova-Antova, R., Aurière, M., Petit, P., Charbonnel, C., et al., Magnetic field structure in single late-type giants: The effectively single giant V390 Aur, A&A 541 (2012) A44

Korn A. J., Richard O., Mashonkina L., et al., Ap. J., 698 (2009), 410

Korotin S., Mishenina T., Gorbaneva T., Soubiran C., NLTE barium abundance in thin and thick disks of the Galaxy, PoS, 11th Symposium on Nuclei in the Cosmos 19-23 July 2010 Heidelberg, Germany

Korotin S., Mishenina T., Gorbaneva T., Soubiran C., The NLTE Barium Abundance in Dwarf Stars in the Metallicity Range of -1 < [Fe/H] < +0.3. MNRAS 415 (2011), 2093

Kosenko D., Blinnikov S.I., Vink J., Modeling supernova remnants: effects of diffusive cosmic-ray acceleration on the evolution and application to observations, A &A 532 (2011), A114

Kovtyukh V.V., Chekhonadskikh F.A., Luck R.E., Soubiran C., Yasinskaya M.P., Belik S.I., Accurate luminosities for F-G supergiants from FeII/FeI line depth ratios, MNRAS 408 (2010), 1568

Kovtyukh V.V., Gorlova N.I., Belik S.I., Accurate luminosities from the oxygen λ7771-4 Å triplet and the fundamental parameters of F-G supergiants, MNRAS 423 (2012) 3268

Kovtyukh V.V., Luck R.E., Chekhonadskikh F.A., Belik S.I., Mode identification of three low-amplitude classical Cepheids: V1334 Cyg, V440 Per and V636 Cas, MNRAS 426 (2012), 398

Kratz K.-L., Farouqi K., Mashonkina L., Pfeiffer B., Nucleosynthesis modes in the high-entropy-wind of type II supernovae, New Astron. Rev. 52 (2008), 390

Krause M., Charbonnel C., Decressin T., Meynet G., Prantzos N., Diehl R., Superbubble dynamics in globular cluster infancy. I. How do globular clusters first lose their cold gas? A&A 546 (2012), L5

Krause M., Charbonnel C., Decressin T., Meynet G., Prantzos N., Superbubble dynamics in globular cluster infancy. II. Consequences for secondary star formation in the context of self-enrichment via fast-rotating massive stars, A & A 552 (2013), A121

Krivoruchenko M. I., Nadyozhin D. K., Razinkova T. L., Simonov Yu. A., Trusov M. A., Yudin A. V., Nuclear matter at high density: phase transitions, multiquark states, and supernova outbursts, 2011, Phys of Atom. Nuclei, 74 (2011), 1

Lagarde, N., Charbonnel, C., Decressin, T., Hagelberg, J.: Thermohaline instability and rotation-induced mixing. II. Yields of ^3He for low- and intermediate-mass stars, A&A 536 (2011), A28

Lagarde, N., Decressin, T., Charbonnel, C., Eggenberger, P., Ekström, S., Palacios, A., Thermohaline instability and rotation-induced mixing. III. Grid of stellar models and asymptotic asterosismic properties from the pre-main sequence to the AGB for low- and intermediate-mass stars at various metallicities, A&A 543 (2012), A108

Lagarde, N., Romano, D., Charbonnel, C., Tosi, M., Chiappini, C., Matteucci, F.: Effects of thermohaline instability and rotation-induced mixing on the evolution of light elements in the Galaxy: D, ^3He, and ^4He, A&A 542 (2012), A62

Lagarde N., Eggenberger P., Charbonnel C., et al., Thermohaline instability and rotation-induced mixing in low and intermediate mass stars: Consequences on global asteroseismic quantities, Eur. Phys. J. Web of Conferences, 43 (2013), 1006

Langanke, K., Martınez-Pinedo, G., Petermann, I., Thielemann, F. K., Nuclear quests for supernova dynamics and nucleosynthesis, Progr. Part. Nucl. Phys. 66 (2011), 319

Lederer, C., .. Rauscher, T., Reifarth, R., .. Wallner, A. et al.: Neutron Capture Cross Section of Unstable ^{63}Ni: Implications for Stellar Nucleosynthesis, Phys. Rev. Lett. 110 (2013), 022501

Lemasle B., Francois P., Genovali K., Kovtyukh V.V. et al., Galactic abundance gradients from Cepheids: alpha and heavy elements in the outer disk, A&A 558 (2013), A31

Lentz, E.J., Mezzacappa, A., Bronson Messer, O.E., Liebendörfer, M., Hix, W.R., Bruenn, S.W., On the Requirements for Realistic Modeling of Neutrino Transport in Simulations of Core-Collapse Supernovae, Ap.J. 747 (2012), 73

Liebendörfer M., Models and direct observables of core-collapse supernovae, PoS, 11th Symposium on Nuclei in the Cosmos, NIC XI July 19-23, 2010 Heidelberg, Germany

Liebendörfer, M., Rampp, M., Janka, H.-T., Mezzacappa, A., Supernova Simulations with Boltzmann Neutrino Transport: A Comparison of Methods, Ap. J. 620 (2005), 840

Liebendörfer M., Fischer T., Fröhlich C., Hix W.R., Langanke K., Martinez-Pinedo G., Mezzacappa A., Scheidegger S., Thielemann F.-K., Whitehouse S.C., Nuclear physics in core-collapse supernovae, New Astron. Rev. 52 (2008), 373

Liebendörfer M., Fischer T., Fröhlich C., Thielemann F.-K., Whitehouse S., Nuclear physics with spherically symmetric supernova models, J. Phys. G, 35 (2008), 014056

Liebendörfer M., Fischer T., Hempel M., Käppeli R., Pagliara, G., Perego, A., Sagert I., Schaffner-Bielich U., Scheidegger S., Thielemann F.-K., Whitehouse, S.C., 2010, Progr. Theor. Phys. Suppl., 186 (2010), 87

Lind K., Charbonnel C., Decressin T., Primas F., Grundahl F., Asplund M., Tracing the evolution of NGC 6397 through the chemical composition of its stellar populations, A&A 527 (2011), A148

Luck R.E., Andrievsky S.M., Kovtyukh V.V., Gieren W., Graczyk D., The Distribution of the Elements in the Galactic Disk.: II. Azimuthal and Radial Variation in Abundances from Cepheids, Astron. J. 142 (2011), 51

Luck R.E., Andrievsky S.M., Korotin S.N., Kovtyukh V.V., Oxygen Abundances in Cepheids, Astron. J. 146 (2013), 18

Lutostansky Yu.S., Lyashuk V.I., Panov, I.V., Production of Transuranium Elements in a Binary Model under Conditions of Pulse Nucleosynthesis, Bull. Russ. Acad. Sci., Physics 75, (2011), 533

Lutostansky Yu.S., Giant Gamow–Teller Resonance: 40 Years after the Prediction, Phys. of Atom. Nuclei 74 (2011) 1176

Lutostansky Yu.S., Lyashuk V.I., Evaluating the Yield of Transuranium Nuclides with Masses of up to A = 270 via Pulsed Nucleosynthesis, Bull. Russ. Acad. Sci., Physics 76 (2012), 462

Lutostansky Yu.S., Panov I.V., The estimation of β-delayed two-neutron emission probability in the A>50 region, Z. Phys. A 313 (1983), 235

Lutostansky Yu.S., Tikhonov V.N., Resonance Structure of the Beta Strength Function, Bull. Russ. Acad. Sci., Physics 76, (2012), 476

Lychkovskiy O., Blinnikov S., Vysotsky M., TeV-scale bileptons, see-saw type II and lepton flavor violation in core-collapse supernova, Eur. Phys. J. C 67 (2010), 213

Maeda K., Röpke F.K., Fink M., Hillebrandt W., Travaglio C., Thielemann F.-K., Nucleosynthesis in Two-Dimensional Delayed Detonation Models of Type Ia Supernova Explosions, Ap. J. 712 (2010), 624

Maeder A., Meynet G., Rotating massive stars: From first stars to gamma ray bursts, Rev. Mod. Phys. 84 (2012), 25

Maeder, A., Meynet, G., Lagarde, N., Charbonnel, C., The thermohaline, Richardson, Rayleigh-Taylor, Solberg-Høiland, and GSF criteria in rotating stars, A & A 553 (2013), A1

Martinez-Pinedo G., Mocelj D., Zinner N.T., Kelic A., Langanke K., Panov I.V., Pfeiffer B., Rauscher T., Schmidt K.-H., Thielemann F.-K., The role of fission in the r-process, Prog. Part. Nucl. Phys. 59 (2007), 199

Mashonkina, L., An Introduction to the Subject of this Workshop, in Non-LTE Line Formation for Trace Elements in Stellar Atmospheres, EAS Publ. Ser. 43 (2010), 33

Mashonkina, L., Accurate Collisional Cross-Sections: Important Non-Lte Input Data, in Non-LTE Line Formation for Trace Elements in Stellar Atmospheres, EAS Publ. Ser. 43 (2010), 79

Mashonkina, L., Resonance broadening and van der waals broadening, in Non-LTE Line Formation for Trace Elements in Stellar Atmospheres, EAS Publ. Ser. 43 (2010), 135

Mashonkina, L., Mechanisms of departure from LTE, in Non-LTE Line Formation for Trace Elements in Stellar Atmospheres, EAS Publ. Ser. 43 (2010), 215

Mashonkina L., Departures from LTE, in chemically stratified atmospheres, in Non-LTE Line Formation for Trace Elements in Stellar Atmospheres, EAS Publ. Ser. 43 (2010), 223

Mashonkina L., Atomic data necessary for non-LTE analysis of stellar spectra, Physica Scripta T134 (2009), 014004

Mashonkina L., Astrophysical tests of atomic data important for the stellar Mg abundance determinations, A & A 550 (2013), A28

Mashonkina L., Christlieb N., Barklem P., Hill V., Beers T.C., Velichko A., The Hamburg/ESO R-process Enhanced Star survey (HERES). V. Detailed abundance analysis of the r-process enhanced star HE 2327-5642, A & A 516 (2010), A 46

Mashonkina L., Gehren T., A&A 364 (2000), 249

Mashonkina L., Gehren T., A&A, 376 (2001), 232

Mashonkina L., Gehren T., Bikmaev I., A&A, 343 (1999), 519
Mashonkina L., Gehren T., Shi, J.R., Korn A.J., Grupp F., A non-LTE study of neutral and singly-ionized iron line spectra in 1D models of the Sun and selected late-type stars, A & A 528 (2011), A87
Mashonkina L., Ryabchikova T., Ryabtsev A., Kildiyarova R., A&A (2009), 495
Mashonkina L., Ryabtsev A., Frebel A., Non-LTE effects on the lead and thorium abundance determinations for cool stars, A&A, 540 (2012), A98
Mashonkina L.I., Vinogradova A.B., Ptitsyn D.A., Khokhlova V.S., Chernetsova T.A., Neutron-capture elements in halo, thick-disk, and thin-disk stars. Strontium, yttrium, zirconium, cerium, Astron. Rep. 51 (2007), 903
Mashonkina L., Zhao, G., Gehren, T., Aoki W., Bergemann M., Noguchi K., Shi J.R., Takada-Hidai, M., Zhang H.W., Non-LTE line formation for heavy elements in four very metal-poor stars, A & A 478 (2008), 529
Massimi C., Rausscher T. et al., ^{197}Au(n,γ) cross section in the resonance region, Phys. Rev. C 81, 044616 (2010)
Massimi, C., Koehler, P., Bisterzo, S., Dillmann, I... Heil, M... Rauscher, T., Reifarth, R., .et al.: Resonance neutron-capture cross sections of stable magnesium isotopes and their astrophysical implications, Phys Rev. C 85 (2012), 044615
Metzger B. D., Martinez-Pinedo G., Darbha S., Quataert E., Arcones A., Kasen D., Thomas R., Nugent P., Panov I. V., Zinner N. T., Electromagnetic counterparts of compact object mergers powered by the radioactive decay of r-process nuclei, MNRAS 406 (2010), 2650
Mishenina T.V., Gorbaneva T.I., Basak N.Yu., Soubiran C., Kovtyukh V.V., The copper and zinc abundances in stars of galactic sub-structures, Astron. Rep. 55 (2011), 689
Mishenina T.V., Gorbaneva T.I., Prantzos N., Soubiran C., Basak N.Yu., Behavior of neutron capture elements in thin and thick disks of the Galaxy, PoS, 11th Symposium on Nuclei in the Cosmos, NIC XI July 19-23, 2010 Heidelberg, Germany
Mishenina T.V., Soubiran C., Kovtyukh V.V., Katsova M.M., Livshits M.A., Li abundance in the stars with solar-type activity, Mem. Soc. Astron. It. Suppl. 75 (2012), 282
Mishenina T.V., Soubiran C., Kovtyukh V.V., Katsova M.M., Livshits M.A., Activity and the Li abundances in the FGK dwarfs, A & A 547 (2012), A106
Mishenina T.V., Soubiran C., Korotin S.A., Gorbaneva T.I., Basak N.Yu., Chemical composition of stars in kinematical substructures of the galactic disk, Assembling the Puzzle of the Milky Way, Le Grand-Bornand, France, Edited by C. Reylé; A. Robin; M. Schultheis; EPJ Web of Conferences, Volume 19 (2012), 05006
Mishenina T.V., Pignatari M., Korotin. S.A, Soubiran C., Charbonnel C., Thielemann, F.-K., Gorbaneva T.I., Basak N.Yu., Abundances of neutron-capture elements in stars of the Galactic disk substructures, A & A 552 (2013), A128
Mishenina T.V, Korotin S.A., Carraro D., Kovtyukh V.V., Yegorova I., Barium and yttrium abundance in intermediate-age and old open clusters, MNRAS 433 (2013), 1436
Moriya T., Tominaga N., Blinnikov S.I., Baklanov P.V, Sorokina E.I., Supernovae from red supergiants with extensive mass loss, MNRAS 415 (2011), 199
Moriya T.J., Blinnikov S.I., Baklanov P.V., Sorokina E.I., Dolgov A.D., Synthetic light curves of shocked dense circumstellar shells, MNRAS 430 (2013), 1402
Morokuma T., Blinnikov S., Baklanov P., Sorokina E., Nomoto K., Shock Breakout in Type II Plateau Supernovae: Prospects for High-Redshift Supernova Surveys, Ap. J. Suppl. 193 (2011), 20
Mosconi M., Raucher T. et al., Neutron physics of the Re/Os clock. I. Measurement of the (n,γ) cross sections of ^{186,187,188}Os at the CERN nTOF facility, Phys. Rev. C 82 (2010), 015802
Mowlavi, N., Eggenberger, P., Meynet, G., Ekstöm, S., Georgy, C., Maeder, A., Charbonnel, C., Eyer, L., Stellar mass and age determinations – I. Grids of stellar models from Z=0.006 to 0.04 and M=0.5 to 3.5Msun, A&A 541 (2012), A41
Nadyozhin D.K., Panov I.V., Weak r-Process Component as a Result of the Neutrino Interaction with the Helium Shell of a Supernova, Astron. Lett. 33 (2007), 385
Nadyozhin D.K., Panov I.V., Neutrino-induced nucleosynthesis in supernovae: synthesis of light elements and neutrino-driven r-process, J. Phys. G 35 (2008), 014061
Nadyozhin D.K., Yudin A.V., Equation of State under Nuclear Statistical Equilibrium Conditions, Astron. Lett. 30, (2004), 634
Nadyozhin D.K., Yudin A.V., The Influence of Coulomb Interaction on the Equation of State under Nuclear Statistical Equilibrium Conditions, Astron. Lett. 31 (2005), 269

Nishimura, N., Fischer, T., Thielemann, F.-K., et al.: Nucleosynthesis in core-collapse supernova explosions triggered by a quark-hadron phase transition, Ap, J. 758 (2012), 9

Ornelas, A., Galaviz, D., Fülöp, Z., Gyüky, G., Kiss, G., Mate, Z., Mohr, P., Rauscher, T et al.: Investigation of α-nuclear potential families from elastic scattering experiments, J. Phys. Conf. Ser. 337 (2012), 012030

Pang, B., Pen, U.-L., Matzner, C. D., Green, S. R., Liebendörfer, M., Numerical parameter survey of non-radiative black hole accretion: flow structure and variability of the rotation measure, MNRAS 415 (2011), 1228

Panov I.V., Dolgov A.D. JETP Lett. (2013), in press

Panov, I.V., Janka H.-Th., On the Dynamics of Proto-Neutron Star Winds and r-Process Nucleo-synthesis, A & A 494 (2009), 829

Panov, I.V., Kolbe, E., Pfeiffer, B., Rauscher, T., Kratz, K.-L., Thielemann F.-K., Calculations of fission rates for r-process nucleosynthesis, Nucl. Phys A 747 (2005), 633

Panov, I. V., Korneev, I. Yu., Thielemann, F.-K., The r-Process in the region of transuranium elements and the contribution of fission products to the nucleosynthesis of nuclei with A < 130, Astron. Lett. 34 (2008), 189

Panov I.V., Thielemann F.-K., Final r-process yields and the influence of fission: the competition between neutron-induced and beta-delayed fission, Nucl. Phys A 718 (2003), 647

Panov, I.V.; Thielemann, F.-K., Fission and the r-Process: Competition between Neutron-Induced and Beta-Delayed Fission, Astron. Lett. 30 (2004), 647

Panov I.V., Korneev I.Yu., Rauscher T., Martinez-Pinedo G., Kelic-Heil A., Zinner N.T., Thielemann F.-K., Neutron-induced astrophysical reaction rates for translead nuclei, A & A 513 (2010), A61

Panov I.V., Korneev I.Yu., Contribution of fission to heavy-element nucleosynthesis in an astrophysical r-process, Astronomy Letters 37 (2011), 864

Panov I.V., Korneev I.Yu., Rauscher T., Thielemann F.-K., r-process reaction rates for the actinides region and beyond, in Seminar on Fission, eds. C.Wagemans, J.Wagemans, P.D'hondt, World Scientific, Singapore p. 255 (2011)

Panov I.V., Korneev I.Yu., Rauscher T., Thielemann F-K., Neutron-induced reaction rates for the r-process. Bull. Russ. Acad. Sci.: Physics, 75 (2011), 484

Panov I.V., Korneev I.Yu., Lyutostanski Yu.S., Thielemann F.-K., Probabilities of delayed processes for nuclei involved in the r-process, Phys. Atom. Nuclei, 76 (2013a), 1

Panov I.V., Korneev I.Yu., Martinez-Pinedo G., Thielemann F.-K., Astron. Lett. 39 (2013b), 150

Paradela C., Rauscher T. et al., Neutron-induced fission cross section of ^{234}U and ^{237}Np measured at the CERN Neutron Time-of-Flight (nTOF) facility, Phys. Rev. C 82 (2010), 034601

Petermann I., Arcones A., Hix W.R., Kelic A., Langanke K., Panov I., Rauscher T., Schmidt K.-H., Thielemann F.-K., Zinner N., Network calculations for r-process nucleosynthesis. J. Phys. Conf. Ser. 202 (2010), 012008

Petermann I., Langanke K., Martínez-Pinedo G., Panov I. V.; Reinhard P.-G., Thielemann F.-K. Have superheavy elements been produced in nature? The Eur. Phys. J. A 48 (2012), 122

Pignatari, M., Herwig, F., The NuGrid research platform: a comprehensive simulation approach for nuclear astrophysics, Nucl. Phys. News 22 (2013), 18

Pignatari, M., Hirschi, R., Wiescher, M., Gallino, R., Bennett, M., Beard, M., Fryer, C., Herwig, F., Rockefeller, G., Timmes, F.X., The ^{12}C+^{12}C Reaction and the Impact on Nucleosynthesis in Massive Stars, Ap. J. 762 (2013), 31

Pignatari, M., Wiescher, M., Timmes F.X., de Boer, R.J., Thielemann, F.-K., Fryer, C., Heger, A., Herwig, F., Hirschi, R.: Production of carbon-rich presolar grains from massive stars, Ap. J. Lett. 767 (2013), L22

Pignatari, M., Zinner, E., Bertolli, M. G., Trappitsch, R., Hoppe, P., Rauscher, T., Fryer, C., Herwig, F., Hirschi, R., Timmes, F.X., Thielemann, F.-K.: Silicon Carbide Grains of Type C Provide Evidence for the Production of the Unstable Isotope ^{32}Si in Supernovae, Ap. J. Lett. 771, L7 (2013)

Pignatari, M., Herwig, F., Hirschi, R., .., Frischknecht U. et al., NuGrid stellar data set. I. Stellar yields from H to Bi for stars with metallicities Z = 0.02 and Z = 0.01, arXiv:1307.6961 (2013)

Potashov M., Blinnikov S., Baklanov P. and Dolgov A., Direct distance measurements to SN 2009ip, MNRAS Lett. 431 (2013), L98

Potashov M., Moriya T.L., et al.,Light-curve modelling of superluminous supernova 2006gy: collision between supernova ejecta and a dense circumstellar medium, MNRAS 428 (2013), 1020

Prantzos, N., Charbonnel, C., Iliadis, C.; Light nuclei in galactic globular clusters: constraints on the self-enrichment scenario from nucleosynthesis, A & A 470 (2007), 179

Rauscher T., Thielemann, F.-K., Astrophysical Reaction Rates From Statistical Model Calculations, At. Data Nucl. Data Tables 75 (2000), 1
Rauscher T., Thielemann F.-K., Predicted cross-sections for photon-induced particle emission, At. Data Nucl. Data Tables, 79 (2001), 47; 88 (2004), 1
Rauscher T., Differences between stellar and laboratory reaction cross sections, J. Phys. Conf. Ser. 202 (2010), 012013
Rauscher T., Astrophysical Rates for Explosive Nucleosynthesis: Stellar and Laboratory Rates for Exotic Nuclei, Nucl. Phys. A 834 (2010), 635
Rauscher T., Relevant energy ranges for astrophysical reaction rates, Phys. Rev. C 81 (2010), 045807
Rauscher T., Astrophysical Reaction Rates as a Challenge for Nuclear Reaction Theory, in Origin of Matter and Evolution of Galaxies: OMEG-2010, AIP Conf. Ser. 1269 (2010), 247
Rauscher T., The Path to Improved Reaction Rates for Astrophysics, Int. J. Mod. Phys. E, 20 (2011), 1071
Rauscher, T.: Sensitivity of Astrophysical Reaction Rates to Nuclear Uncertainties, Ap. J. Supp. 201 (2012), 26
Rauscher, T.: Formalism for Inclusion of Measured Reaction Cross Sections in Stellar Rates Including Uncertainties and Its Application to Neutron Capture in the s-process, Ap. J. Lett. 755 (2012), L10
Rauscher, T., Kiss, G.G., Szücs, T., Fülöp, Z., Fröhlich, C., Gyürky, G., Halász, Z., Kertész, Z., Somorjai, E.: Astrophysical analysis of the measurement of (α,γ) and (α,n) cross sections of ^{169}Tm, Phys. Rev. C 86, 015804 (2012)
Rauscher, Dauphas, N., Dillmann, I., Fröhlich, C., Fülöp, Z., Gyürky, G.: Constraining the astrophysical origin of the p-nuclei through nuclear physics and meteoritic data. Rep. Progr. Phys. 76, 066201 (2013)
Rauscher T., Solution of the α-Potential Mystery in the γ Process and Its Impact on the Nd/Sm Ratio in Meteorites, Phys. Rev. Lett. 111 (2013), 061104
Röpke F.K., Hillebrandt W., Schmidt W., Niemeyer J.C., Blinnikov S.I., Mazzali P.A., A Three-Dimensional Deflagration Model for Type Ia Supernovae Compared with Observations, Ap. J. 668 (2007), 1132
Rosswog S., Korobkin O., Arcones A., Thielemann F.-K.,The longterm evolution of neutron star merger remnants I: the impact of r-process nucleosynthesis, arXiv:1307.2939 (2013)
Sagert I., Fischer T., Hempel M., Pagliara G., Schaffner-Bielich J., Mezzacappa A., Thielemann F.-K., Liebendörfer M., Signals of the QCD Phase Transition in Core-Collapse Supernovae, Phys. Rev. Lett., 102 (2009), 081101
Schaerer D., Charbonnel C., A new perspective on globular clusters, their initial mass function, and their contribution to the stellar halo and to cosmic reionisation, MNRAS 413 (2011), 2297
Schaffner-Bielich J., Fischer T., Hempel M., Liebendörfer M., Pagliara G., Sagert I., Can a Supernova Bang Twice? Prog. Theor. Phys. Suppl. 186 (2010), 93 (2010)
Scheidegger S., Fischer T., Whitehouse S.C., Liebendörfer M., Gravitational waves from 3D MHD core collapse simulations, A & A 490 (2008), 231
Scheidegger S., Käppeli R., Whitehouse S.C., Fischer T., Liebendörfer M., The influence of model parameters on the prediction of gravitational wave signals from stellar core collapse, A & A 514 , A51 (2010)
Scheidegger S., Whitehouse S.C., Käppeli R., Liebendörfer M., Gravitational waves from supernova matter, Class. Quant. Grav. 27 (2010), 114101
Sitnova T., Mashonkina L., The r/s-process contribution to heavy elements in the halo star HD 29907, Astron. Lett. 37 (2011), 480
Sitnova T.M., Mashonkina L.I., Ryabchikova T.A., Influence of departures from LTE on oxygen abundance determination in the atmospheres of A-K stars, Astron. Lett. 39 (2013), 126
Skakun Y., Rauscher T., Astrophysical S-Factors and Reaction Rates of Threshold (p,n)- Reactions on $^{99-102}$Ru, in Origin of Matter and Evolution of Galaxies: OMEG-2010, AIP Conf. Ser. 1269 (2010), 390
Stasinska G., Chabonnel C., et al., The chemical composition of TS 01, the most oxygen-deficient planetary nebula. AGB nucleosynthesis in a metal-poor binary star, A & A 511(2010), A44
Suwa Y., Kotake K., Takiwaki T., Whitehouse S.C., Liebendörfer M., Sato K., Explosion Geometry of a Rotating 13Mo star driven by the SASI-aided neutrino-heating supernova mechanism, Publ. Astron. Soc. Jap. 62 (2010), L49
Tagliente G., Rauscher T., et.al., The ^{92}Zr(n,γ) reaction and its implications for stellar nucleosynthesis, Phys. Rev. C 81 (2010), 055801
Takashi J., Moriya T.J., Blinnikov S.I., Keiichi M., Sorokina E.I., Taddia F., Sollerman J., An Analytic Bolometric Light Curve Model of Interaction-Powered Supernovae and its Application to Type IIn Supernovae, MNRA (2013), submitted

Thielemann F.-K., Argast D., Brachwitz F., Hix W. R., Höflich P., Liebendorfer M., Martinez-Pinedo G., Mezzacappa A., Panov I., Rauscher T.; Nuclear cross sections, nuclear structure and stellar nucleosynthesis, Nucl. Phys. A, 718 (2003), 139
Thielemann, F.-K., Fröhlich, C., Hirschi, R., Liebendörfer, M., Dillmann, I., Mocelj, D., Rauscher, T., Martinez-Pinedo, G., Langanke, K., Farouqi, K.,. Kratz, K.-L., Pfeiffer, B., Panov, I., Nadyozhin, D.K., Blinnikov, S.I., Bravo, E., Hix, W.R., Höflich, P., Zinner, N.T., Production of intermediate-mass and heavy nuclei, Prog. Part. Nucl. Phys. 59 (2007), 74
Thielemann, F.-K., Mocelj, D., Panov, I., Kolbe, E., Rauscher, T., Kratz, K.-L., Farouqi, K., Pfeiffer, B., Martinez-Pinedo, G., Kelic, A., Langanke, K., Schmidt, K.-H., Zinner, N., The R-Process: Supernovae and Other Sources of the Heaviest Elements, Int. J. Mod. Phys. E 16 (2007), 1149
Thielemann F.-K., Dillmann I., Farouqi K., Fischer T., Fröhlich C., Kelic-Heil A., Korneev I., Kratz K.-L., Langanke K., Liebendörfer M., Panov I.V., Martinez-Pinedo M. and Rauscher T., The r-, p-, and vp-Process. 2010 J. Phys.: Conf. Ser. 202 (2010), 012006
Thielemann F.-K., Arcones, A., Käppeli, R., Liebendörfer, M., Rauscher, T., Winteler, C., Fröhlich, C., … Panov I.V., et al., What are the astrophysical sites for the r-process and the production of heavy elements? Prog. Part. Nucl. Phys. 66 (2011) 346
Thielemann F.-K., Hirschi R., Liebendörfer M., Diehl R., Massive Stars and their Supernovae, arXiv:1008.2144, in Astronomy with Radioactivities, LNP 812 (2011), 153
Tolstov A.G., Simulations of Multigroup Relativistic Radiative Transfer for Shock Waves in Supernovae, Astron. Lett. 36, 109, (2010)
Tolstov A.G., Badjin D.A., Blinnikov S.I., Postnov K.A., Thermal emission in gamma-ray burst afterglows, MNRAS 432 (2013), 2454
Tolstov A.G., Blinnikov S.I., Nadyozhin D.K., Coupling of matter and radiation at supernova shock breakout, MNRAS 429 (2013), 3181
Tominaga N., Blinnikov S.I., Tolstov A.G., Multigroup radiative transfer in supernova shock breakout models, Astron. Letters 37 (2011), 194
Tominaga N., Morokuma T., Blinnikov S., Baklanov P., Sorokina E., Nomoto K., Shock Breakout in Type II Plateau Supernovae: Prospects for High-Redshift Supernova Surveys, Ap. J. Suppl. 193 (2011), 20
Tominaga, N., Blinnikov, S.I., Nomoto, K., Supernova Explosions of Super-asymptotic Giant Branch Stars: Multicolor Light Curves of Electron-capture Supernovae, Ap. l, Lett. 771 (2013), L12
Velichko A., Mashonkina L., Nilsson H., Non-LTE line formation for Zr I-Zr II in stellar atmospheres, Astron. Lett. 36 (2010), 664
Winteler C., Käppeli R., Perego A., Arcones A., Vasset N., Nishimura N., Liebendörfer M., Thielemann F.-K., Magnetorotationally Driven Supernovae as the Origin of Early Galaxy r-process Elements? Ap. J. Lett. 750 (2012), L22
Woosley S.E., Blinnikov S., Heger A., Pulsational pair instability as an explanation for the most luminous supernovae, Nature 450 (2007), 390
Yudin A.V., Nadyozhin D.K., The Approximation of Neutrino Heat Conduction with Neutrino Scattering, Astron. Lett. 34 (2008), 198
Yudin A.V., Excluded Volume Approximation For Supernova Matter, PoS, 11th Symposium on Nuclei in the Cosmos, NIC XI July 19-23, 2010 Heidelberg, Germany
Yudin A.V., Excluded-volume approximation for supernova matter, Astron. Lett. 37 (2011), 576
Yudin A. V., Razinkova T. L., Nadyozhin D. K., A model equation of state for studying structure and evolution of super dense stars with phase transition, Astron. Lett. 39 (2013), 161
Yushchenko A.V., Gopka V.F., Goriely S., Musaev F.., Shavrina A.V., Kim C., Woon Kang Y., Kuznietsova J., Yushchenko V.A.; Thorium-rich halo star HD221170: Further Evidence against the universality of the r-process, A & A 430 (2005), 255
Yushchenko A.V., Dorokhova T.N., et.al., The Atmosphere Parameters and the Line Profile Variations of ρ Puppis, J. Korean Astron. Soc. 43 (2010), 65
Yushchenko V. A., Chemical composition of peculiar star HD91375 - The Member of Sirius Moving Group . OAP 22 (2011), 73
Yusof, N., Hirschi, R., Meynet, G., Crowther, P.A., Ekström, S., Frischknecht, U., Georgy, C., Abu Kassim, H., Schnurr, O.: Evolution and fate of very massive stars, MNRAS 433 (2013), 1114