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Project No: 321263

Project Acronym: FISH

Project Full Name: FaInt Supernovae and Hypernovae: Mechanism
and Nucleosynthesis

ERC-AG

Final Activity Report

Period covered: from 01/01/2013 **to** 31/12/2016

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Principal Investigator name:
Prof. Friedrich-Karl Wilhelm Thielemann

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UNIVERSITAET BASEL

Final Activity Report

GENERAL INFORMATION

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Final Activity Report

Summary of the major project achievements over the entire lifetime of the project

The information provided in this section will only be available to ERC staff, to members of the ERC panels, and to the Scientific Council

Explain in a clear manner the work performed during the entire lifetime of the project along the main objectives/activities of the project listed in the Description of Work (DoW). Please indicate the publications linked to these objectives/activities.

Please specify the outcome in terms of:

- research and technological achievements along the main objectives/activities (in line with the DoW)

The ERC project FISH relates to the explanation of FaInt Supernovae and Hypernovae (including the manifestation in form of Gamma-Ray Bursts - GRBs). They are the expected outcome as endpoints of the evolution of massive stars, ranging from regular core-collapse supernovae with neutron star formation to the formation of black holes. Weak supernova explosions, still leading to neutron stars, cause faint supernovae. GRBs are accompanied by central black hole formation (either via the core collapse of massive stars - long-duration GRBs - or the merger of two neutron stars or a neutron star and a black hole - short-duration GRBs). The modeling relies on the following sub-topics: progenitor stellar models, the nuclear equation of state, energy generation via nuclear reactions, neutrino transport, relativistic multi-D magneto-hydrodynamics, leading to explosive ejecta which contribute in their nucleosynthetic composition to the evolution of galaxies. They are attributed in the following to the work packages of the initial proposal.

WP1. Neutrino transport in high density proto-neutron stars and (black hole) accretion disks (III)

WP2. Fluid instabilities and multi-D magneto-hydrodynamics (in rotating models) based on the IDSA (isotropic diffusion source approximation) (IV)

WP3. Improved Microscopic Input Physics and Comprehensive Nucleosynthesis Yield Predictions

(a) equation of state (EoS) of matter at extreme densities (and temperatures) (I)

(b) nuclear reaction predictions across the nuclear chart (II)

(c) nucleosynthesis in/of explosive ejecta and impact in galactic evolution (V)

We have regrouped these topics in the order I through V (see brackets behind subtopics of WPs), where topics I through III relate to input physics and the treatment of it in multi-D modeling, topic IV to the actual modeling of the events, and topic V to their nucleosynthetic impact during the evolution of galaxies. Our main achievements are/have been:

I. An analysis of the asymmetry energy of nuclear matter, determination of its density dependence, analysis of the effect of finite temperatures, and constraints from astrophysical observations. As one of the key results we obtained the density functionals SFHo and SFHx (17) with constraints on the asymmetry energy S (29-31 MeV) and its density dependence L (40-60 MeV), which lead to realistic mass-radius relations and good estimates of maximum neutron star masses slightly above 2 Msol (as observed recently). These (and other) results by M. Hempel (initially SNF, later ERC) led to further developments with ERC graduate student O. Heinemann. During the years 2013 through 2014 the publications (4, 6, 12, 14, 17, 19, 21, 34) are related to EoS issues. Nucleon potentials have been analyzed which affect neutrino spectra in supernova models. Equilibrium constraints from heavy-ion collisions have been utilized to determine the low-density EoS (55), evaluating the role of light nuclei in SN explosions. All of this has culminated in an excellent review for Rev. Mod. Phys. on the EoS (93), which has just been published and utilized in e.g. multi-D core collapse simulations by postdoc

Kuo-Chuan Pan (ERC). Especially the role of quark matter at high densities has been analyzed in 66, 86, 90, and 91. The impressive results of the PhD thesis of Oliver Heinemann (ERC), shown to some extent already in Proc. 22 (and to be published in full soon) lead to the conclusion that present-day EoS studies, consistent with 2 Msol neutron star masses, permit to cause supernova explosions via the hadron-quark phase transition.

II. Determination of key nuclear input parameters/uncertainties (nuclear masses, fission barriers, optical potentials for particle capture, level densities of excited states, giant electromagnetic resonances for gamma transitions, direct capture) in order to provide complete sets of reaction cross sections across the nuclear chart. One of the highlights is the resolution of the long-standing “apparent” alpha potential problem for heavier nuclei which disappears if Coulomb Excitations are included properly (15, 18). Based on this and many other efforts by PD T. Rauscher (ERC), a complete set of most advanced nuclear reaction rates has been available to us for all applications in this ERC project. In addition, efforts by collaborations of PhD student M. Eichler (SNF), visitor I. Panov (SNF SCOPES) and F.-K. Thielemann (ERC), related to beta-decay half-lives of heavy nuclei, fission barriers, and fission fragment distributions led to major advances in applications of these nuclear properties/reactions when applied to nucleosynthesis calculations. Such improved nuclear input is summarized in (3, 5, 8, 9, 11, 15, 18, 20, 24, 25, 26, 27, 28, 30, 39, 40, 41, 44, 45, 56, 57, 59, 60, 61, 62, 63, 69, 71, 75, 81, 83, 84, 85, 88, and Proc. 5, 7, 9, 11)

III. PD M. Liebendörfer (ERC) has established during prior work the BOLTZTRAN neutrino transport scheme (based on the full solution of the relativistic Boltzmann transport equation for neutrinos). Further advances geared towards the computationally highly-demanding multi-D magneto-hydrodynamics resulted in the IDSA (isotropic diffusion source approximation) which can cover both, the free streaming and the diffusion limit of the Boltzmann transport equation. A mathematically rigorous derivation provided the prove of concept (1) of this method, which by now has been tested in a number of publications (4, 33, 36, 46, 48, 53, 64, 65, 67, 74, and Proc. 3). In parallel, a new algorithm to compute optical depths (for neutrinos) in multidimensional hydrodynamic simulations (MODA) has been developed (29), which is especially applicable to compact objects that are rotationally deformed (e.g. [33]), and also for the advanced treatment of neutron star mergers (36, 49, 57, 74). PhD student M. Frensel (ERC) has been making strong advances on neutrino transport and the treatment of collective neutrino oscillations in (finally resulting) black hole accretion disks (89). A. Lohs has obtained new results on the effect of muon and tau neutrinos in core collapse neutrino transport (55 and Proc. 21).

IV. Postdocs R. Cabezón, K.-C. Pan, and T. Kuroda, and PD M. Liebendörfer formed the core ERC-team on multi-D hydrodynamics. R. Cabezón introduced a highly sophisticated multi-D smooth particle hydrodynamics (SPH) code (SPHINX). K.-C. Pan had extended experience in the public-domain grid-based multi-D hydro-code FLASH with radiation transport. T. Kuroda came with a fully general relativistic (GR) multi-D hydrocode, permitting to follow black-hole formation. The local grid code FISH (developed by M. Liebendörfer) includes a Newtonian treatment of magneto-hydrodynamics, combined with a relativistic pseudopotential and spectral neutrino transport. In a first step the IDSA neutrino transport was implemented in all these codes and a large set of comparison calculations for core collapse have been performed. In addition, comparisons investigations were done with respect to spherically symmetric 1D calculations with our full GR-code AGILE-BOLTZTRAN. The resulting extended paper (unique among the supernova community) is one of the great successes of this ERC grant. It is included here still as an attachment (code_comparison), but will be submitted very soon. It was the basis for indicating the most appropriate scheme during different periods of the simulations, in order to devise the best strategy for

tackling the core theme of the project, related to gravitational collapse. The very exciting news is that all schemes lead to essentially the same results for our core-collapse simulations which cause explosions, as well as up to the very last moments also in cases when black hole formation sets in, validating the use of pseudo GR-potentials in Newtonian schemes. Extended results have been obtained in a parallel 1D effort, based on an approximate neutrino heating treatment, the “PUSH* approach which mimics neutrino heating in 3D (43, Proc. 18, 19), multi-D, partially including magneto-hydrodynamics (22, 33, 35, 46, 48, 50, 53, 64, 65, 82, Proc.2, 3, 12, 13, 17, 20 came to similar conclusions). In a number of studies also gravitational wave predictions have been obtained (22, 65, 82, Proc. 13). These multi-D studies are still in progress, sampling the full mass range of stellar progenitor masses (with and without rotation) to follow the transition from regular core-collapse supernovae, to faint supernovae, and finally black hole formation. Presently still running simulations with the FLASH-IDSa and M1 codes will still be published soon. Further multi-D studies in other explosive events like type Ia supernovae, and neutron star mergers (i.e. short-duration GRBs) have benefitted from these code developments (23, 31, 35, 42, 44, 49, 72, 80, Proc. 16).

V. Based on the evolution of (rotating) massive stars (the progenitors of high mass core-collapse systems), the composition of the wind ejecta has been predicted, involving for the first time (due to convective instabilities) heavy s-process nuclei (10, 16, 68, 80). Such analysis has also been applied to AGB stars (26, 58, 59, 60, 75). p- or gamma-process studies in supernova explosions have been undertaken in (11, 15, 20, 27, 28, 30, 40, 45, 62, 85, 88). The neutrino wind ejecta of massive core collapse systems have been reviewed in (2). Detailed explosive nucleosynthesis predictions have been made within the “PUSH approach” (43, Proc. 18). Polar jet ejecta of magnetars (resulting from core-collapse with fast rotation and high magnetic fields), especially with respect to heavy element r-process nucleosynthesis, have been obtained with magneto-hydrodynamic simulations for various rotation rates and magnetic fields. Especially the role of MHD effects in comparison to neutrino heating (46, 94) has been analyzed. Neutron-star merger calculations with detailed nucleosynthesis predictions (and tests of nuclear input physics like mass models, fission and beta-decay) were performed in (3, 5, 23, 44, 56, 57, 69), dominantly addressing dynamic ejecta from the emerging disk. Later phases, dominated by a neutrino wind, have been examined in (36, 49, Proc. 12), analyzing the option of also producing matter lighter than the second r-process peak. A review about these environments (Ann. Rev. Nucl. Part. Sci., in press) is attached (annrevfktfinalff). It turns out, that two options (magnetar jets and neutron star mergers) are viable candidates for a strong r-process, producing the heaviest elements in nature. The question is related to the role both sites play at different times during galactic evolution. ERC PhD B. Wehmeyer (ERC) has addressed this question (47, 51, 92, Proc. 15, and the above mentioned review) coming to the conclusion that magnetar jets are needed to explain observations related to the early Galaxy, while present solar abundances can result from a combination of both types of events during galactic evolution. A detailed analysis by PD I. Cherchneff (ERC) how all of the ejecta addressed here (especially those from supernovae) lead also to dust formation has been presented in (13, 54, 70, 73, 76, 78, 79). Finally, we have also been involved in collaborations with astronomical observers to monitor the evolution of heavy element abundances during the evolution of galaxies, as a function of metallicity (7, 38, 51, 52, 68, Proc. 12, 15).

* citation numbers correspond to published results (see Annex A1), those in proceedings are listed as Proc. X, where X related to the number within the listed proceedings articles. We attach three unpublished publications (a review on neutron star mergers for Ann. Rev. Nucl. Part. Phys., a bookchapter for the Springer Handbook on Supernovae, and our code comparison paper to be submitted).

- novel and/or unconventional methodologies

Topic I:

Forefront research for the high density equation of state (EoS) by ERC member PD M. Hempel and collaborators, especially including the hadron-quark phase transition, has led to a full set of EoS tables to be tested in astrophysical application (see <http://phys-merger.physik.unibas.ch/~hempel/eos.html> and <http://compose.obspm.fr>)

Topic II:

Advances after solving the so-called alpha-potential mystery and the theoretical analysis of many joint research efforts with experimental colleagues have led to a full set of nuclear reaction rates across the nuclear chart by ERC member PD T. Rauscher (<https://nucastro.org>)

Topic III:

Making available to the public the 1D general relativistic adaptive grid hydrodynamics code with spectral neutrino transport (AGILE-BOLTZTRAN) (<https://physik.unibas.ch/~liebend/download>). In a similar way the isotropic diffusion source approximation method (IDSA) will be made available to the public, which was tested extensively against full BOLTZTRAN solutions, but saves essential amounts of computing time in multi-D studies.

In addition, novel techniques to treat the horizon at black hole formation have been investigated by master student N. Maksimovic:

When a black hole is formed in a computer simulation, a coordinate singularity appears in traditional comoving coordinates. N. Maksimovic investigated in his project thesis three different coordinate systems that could help to circumvent this singularity. He showed that a very attractive alternative option is the use of observer time coordinates because they directly focus on the observable aspects of black hole formation after stellar core collapse. The compatibility of these coordinate choices with the hydrodynamics codes was tested in his master thesis.

Topic IV - multi-D magneto-hydrodynamics:

1) The code 3D-FISH has been updated to include the last public version of the IDSA (1) and a multi-dimensional Poisson solver. A. Perego et al. (29) published the MODA algorithm, which detects the neutrino spheres as hypersurfaces in 3D space and master student J. Michaud has implemented, tested and documented an improvement for the coupling of trapped and streaming particles in the IDSA. Simulations are running robustly from stellar collapse to some hundred milliseconds postbounce time and include the evolution of magnetic fields. However, rotating models are affected by dissipation of angular momentum on the equidistant Cartesian mesh and the implementation of adaptive mesh refinement (AMR) has turned out to be difficult. In order to have alternatives and to work out the impact of the angular momentum loss we implemented the neutrino transport based on the IDSA in other hydrodynamics codes with complementary strengths and weaknesses:

2) K.-C. Pan (ERC) implemented the IDSA in the public domain code FLASH (<http://flash.uchicago.edu>). FLASH is a parallel, multidimensional hydrodynamics code based on block-structured AMR. Our simulation setup includes the neutrino treatment with our IDSA solver. We use a third-order piecewise parabolic method (PPM) for spatial reconstruction, the HLLC Riemann solver, and the Hybrid slope limiter. AMR is implemented using PARAMESH4. We can use the full set of EOSs listed under topic I in FLASH with the help of <https://stellarcollapse.org>. FLASH-IDSA as well as FISH-IDSA were improved by implementing GPU acceleration with Open

ACC. In addition, effective GR, the possibility of rotation, and routines permitting to predict gravitational wave emission have been implemented. First CCSN results have been published in (31). 2D (axis-symmetric) simulations to black hole formation have been performed and reported in (Proc. 20). 3D simulations (with and without rotation) are still running successfully beyond 300ms after bounce and will be published soon.

3) R. Cabezón (ERC) has implemented the IDSA in the code SPHYNX. SPHYNX is a state-of-the-art 3D SPH code that has been developed in Basel and adapted to perform numerical simulations of core collapse supernovae (see 35). It includes the Integral Approach to Derivatives and a flexible family of interpolating kernels, that has recently been proven to improve considerably the accuracy of SPH simulations. For the simulation of faint supernovae and hypernovae, the use of such a Lagrangian approach provides a complementary tool to the other available mesh codes. The intrinsic adaptive nature of SPH grants it with an advantage in simulating the formation and evolution of the proto-neutron star with very high resolution, and its excellent energy and momentum conservation properties allow to simulate rotating progenitors with confidence. Besides, SPHYNX includes an accurate 3D gravitational solver and it is MPI+OpenMP parallelized. So far, SPHYNX had been successfully coupled with the Advanced Spectral Leakage and the 3D implementation of the IDSA .

4) The “M1” code has originally been developed by postdoc ERC T. Kuroda (see e.g. 22) It has been improved further to solve spectral neutrino transport of the radiation energy and momentum based on a truncated moment formalism employing an analytical closure relation (the M1 scheme). It implements multi-dimensional and fully general relativistic equations. Regarding neutrino opacities, we take into account the so-called standard set in state-of-the-art simulations, in which inelastic neutrino-electron scattering, thermal neutrino production via pair annihilation and nucleon-nucleon bremsstrahlung are included. In addition to gravitational redshift and Doppler effects, these energy-coupling reactions are incorporated in the moment equations in a covariant form. The code is designed to evolve the Einstein field equation together with the GR radiation hydrodynamic equations in a self-consistent manner while satisfying the Hamiltonian and momentum constraints. Similar to FLASH-IDSA, extended runs to follow the transition from regular core-collapse supernovae over faint supernovae to black hole formations are still underway and will be published during 2017. The full GR treatment provides the best results for black hole formation.

While none of these codes (1)-(4) is perfect on its own, they have complementary uncertainties and virtues, e.g. (grid vs. SPH, IDSA vs. M1, effective potential vs. GR, etc.). The code comparison project discussed under IV in the previous section led to a systematic comparison of these four codes for the collapse and postbounce evolution of a whole set of progenitor stars. The exciting news is that the results with respect to supernova explosions as well as black hole formations are very similar!

Topic V:

Master student Etienne Kaiser has utilized the MESA stellar evolution code for a whole set of massive stars (mesa.sourceforge.net/) and could reproduce similar investigations by Sukhbold & Woosley obtained with an early release of the MESA code. In addition, he performed extensive tests for uncertainties based on the treatment of convective overshooting and implemented a large nucleosynthesis network, which permits to have a full set of stellar progenitors with an extended set of nuclear species for the later core-collapse simulations.

All nucleosynthesis calculations listed in the previous section under topic V have been performed with the nucleosynthesis codes BASNET (see e.g. 10) and WINNET (see e.g. 44), both developed in Basel. These are implicit codes for the solution of extended sets of extremely stiff ordinary

differential equations, utilizing sparse matrix techniques (PARDISO: www.pardiso-project.org/) for large systems up to about 5000 species. The nuclear input originates for reactions from <https://nucaastro.org>, (T. Rauscher's webpage) plus experimental input from the JINA Reaclib (<https://groups.nsl.msui.edu/jina/reaclib/db/>), based on an early REALIB version by F. Thielemann), as well as advanced predictions of masses, half-lives, fission barriers and fission fragment distributions from the sources cited under topic II.

The formation of molecules and dust in expanding stellar (and explosive) ejecta is followed by similar stiff sets of equations as the nucleosynthesis calculations discussed above, but involving chemical rather than nuclear reactions and species. The solution also follows a scheme for stiff differential equations, known as the GEAR method similar to the one used in BASNET and WINNET. Details are given in the above section V and in the papers by ERC team member Isabelle Cherchneff.(see e.g. 79).

The so-called chemical evolution of galaxies describes the time evolution of element (and isotope) species during galactic evolution, due to the ejecta from stellar winds and stellar explosions. One way to understand possible large spatial variations in the early Galaxy, due to still sparse events of different types requires to abolish the so-called instantaneous mixing approximation (IMA), which has been used widely in the past. r-process elements, resulting from rare neutron star mergers or magneto-rotational supernovae (leading to magnetars) can only be treated with such an approach. ERC PhD student B. Wehmeyer has developed the ICE code (inhomogeneous chemical evolution), which can treat such applications (47 and Proc. 10).

- inter and cross disciplinary developments

the project includes subprojects and collaborations which range from experimental and theoretical nuclear physics with relation to nuclear reactions and the nuclear equation of state, over particle physics with relation to neutrino-matter interactions and neutrino oscillations, stellar evolution with rotation and magnetic fields, general-relativistic magnetohydrodynamic simulations of core collapse and compact object collisions/mergers, up to specific nucleosynthesis predictions for the ejecta of such events, plus their impact in the chemical evolution of galaxies in close contact with astronomical observers.

We think this is quite a fruitful and successful basis for a very inter- and cross-disciplinary approach to very timely and important questions, addressing the formation and collisions/mergers of compact objects and the role of their explosive ejecta in the evolution of galaxies.

- knowledge and technology transfer

This is related mostly to numerical methods in multi-D hydrodynamics and radiation transport, plus the implementation on parallel machines

We will make the IDSA code publically available on the webpage of the Physics Department <http://phys-merger.physik.unibas.ch/users/group/> and we are contributing subroutines in the framework of a Swiss High Performance Computing project (PASC) to a trans-disciplinary radiative transfer library that is meant to be used in different scientific domain applications.

In addition, all the websites we list in the novel and/or unconventional methodologies section provide essential information and knowledge for a large community at the intersection of nuclear/particle physics, astrophysics, and computational magneto-hydrodynamics.

- enhancing the immediate research environment

The ERC advanced grant FISH permitted to enhance strongly our previously existing research which focused essentially on topics in nuclear astrophysics. It made available the resources to add a strong group in computational magneto- and radiation hydrodynamics. With the combined workforce a whole pipeline from nuclear input, over stellar evolution, stellar explosions, up to dust formation and galactic evolution could be established.

- establishment and/or consolidation of the research group and team composition

1.1.2013: the first graduate student (Maik Frensel) started immediately with the beginning of the project (working on neutrino transport and oscillations in black hole accretion disks), together with senior personnel PD Matthias Liebendörfer (MHD hydro-dynamics and neutrino transport), PD Thomas Rauscher (nuclear reaction input to nucleosynthesis aspects of faint supernovae and hypernova) as well as PI Friedrich Thielemann. The team was aided by then SNF postdoc M. Hempel (later ERC), being highly active in providing nuclear equation of state input for all simulations. February 2013: the computer cluster was delivered and installed, three postdoc positions were advertised.

July 2013: postdoc Ruben Cabezon (PhD Barcelona/Spain), working on 3D smooth particle hydrodynamics started on the project.

August 2013: postdocs Takami Kuroda (PhD University of Tokyo), working on general relativistic hydrodynamics, which permits black hole formation, started his contract; also postdoc Kuo-Chuan Pan (PhD University of Illinois), working on 3D hydrodynamics with the FLASH grid-based code, started his contract.

March 2014: graduate student Benjamin Wehmeyer, working on the impact of MHD jets and neutron star merger ejecta on the „chemical evolution“ of galaxies, started his contract.

April 2014: graduate student Oliver Heinemann, working on the equation of state of matter at extreme conditions, related to maximum neutron star masses and the transition to the collapse to black holes, started his contract (partially supervised M. Hempel).

March 2015: postdoc A. Lohs (PhD TU Darmstadt), with a background on muon and tau neutrino interactions with matter, joined the team. While he stayed on the ERC payroll only four five months, he has been helping the whole team until the end of the project, paid then by Basel University.

August 2015: PD Isabelle Cherchneff joined the team (until the end of the project), being responsible for predicting chemical reactions and dust formation in stellar winds and all explosive events being part of the project.

October 2016: After postdoc Kuo-Chuan Pan left for a new position at Michigan State University, Matthias Hempel joined the team also formally, although he was involved since the beginning and especially by supervising PhD student Oliver Heinemann on EoS issues.

This remaining team stayed until the end of the grant (December 2016). Benjamin Wehmeyer and Maik Frensel had their thesis defense in December. Remaining overhead means permitted to pay Oliver Heinemann (and his supervisor Matthias Hempel) until March 2017 and the thesis defense.

The overall impact of the project could be strongly enhanced due to the fact, that we had additional support by a PASC grant from the Swiss high performance computing facility in Lugano, which paid salaries as well as provided the required computing facilities and CPU hours to perform the computationally expensive simulations of this project.

While this summary lists only the team members paid by the ERC, PhD students Marius Eichler (SNF) and Kevin Ebinger (SNF) contributed essentially with respect to nucleosynthesis in neutron star mergers and effective 1D core-collapse simulations, which - mimicking multi-D simulations - permitted large scale predictions for the end points of stellar evolution from regular core-collapse supernovae, over faint supernovae, to the formation of black holes.

- others

n/a

Publishable brief summary of the achievement of the project

This section, which should not exceed 1 page (approx. 600 words), might be used for dissemination of the project progress/results to the general public/scientific community. For this reason, please do not reproduce here the project abstract, which is already available in CORDIS.

Stand alone description of the project and its outcomes

The project includes subprojects which range from experimental and theoretical nuclear physics with relation to (i) the nuclear equation of state (required for the collapse of matter to highest densities, possibly permitting the collapse to a black hole); (ii) nuclear reactions (permitting to follow the energy generation in explosions and the prediction of the elemental and isotopic ejecta composition); over particle physics with relation to (iii) neutrino-matter interactions, neutrino oscillations and the related neutrino (radiation) transport; late stages of stellar evolution with rotation and magnetic fields leading to (iv) general-relativistic magneto-hydrodynamic simulations of core collapse and compact object mergers; up to (v) specific nucleosynthesis predictions for the ejecta of such events, plus their impact in the chemical evolution of galaxies in close contact with astronomical observers.

Thus, this inter- and cross-disciplinary approach addresses the formation and mergers of compact objects, accompanied by explosive events whose ejecta play a key role in the evolution of galaxies.

We have provided essential aspects of the input physics: (1) a data base of nuclear equations of state in agreement with present knowledge from nuclear physics and astronomical observations

<http://phys-merger.physik.unibas.ch/~hempel/eos.html>, (2) a data base of nuclear reactions across the nuclear chart <http://nucastro.org/reaclib.html>, (3) the isotropic diffusion source approximation (IDSA) code for multi-dimensional neutrino transport on our webpage

<http://phys-merger.physik.unibas.ch/users/group/>

A detailed code comparison for (4) magneto-hydrodynamic simulations of core collapse with an SPH code (SPHINX), the open source grid-based code FLASH, our 3D MHD code FISH, and the general relativistic code M1 has been performed, analyzing in which regime which treatment is suited best, which led to extended production runs for such collapse calculations. (5) nucleosynthesis predictions for magnetars have been obtained with varying rotation rates and magnetic fields. Similar investigations have been done for neutron star mergers. (6) The results have been implemented to predict the dust composition originating from such events and (7) to understand the temporal evolution of the heaviest elements during the evolution of galaxies and whether they are in agreement with astronomical observations.

A major achievement was to understand the fate of massive stars and the dividing line between supernova explosions and black hole formation, with an intermediate range leading to faint supernovae. One interesting point is that the initial (somewhat spherically symmetric) expectation that fallback plays a major role after an apparent initially successful explosion, is incorrect. In multi-D simulations the “fallback” is rather a continuous process, causing increasingly weaker explosions up to the point of black hole formation. This behavior is mirrored in our effective 1D simulations which reproduces the observed trend in explosion energies and ^{56}Ni ejecta. Our present investigations show - up to now - only the regular core-collapse supernova branch and the “faint” branch. While we undertook extensive collapse simulations with varying rotation and magnetic fields, causing in extreme cases polar jets and central magnetars with magnetic fields of 10^{15} Gauss (and the formation of large amounts of heavy elements), we were not yet successful in following up on black hole formation events with fast rotation and high magnetic fields in their post collapse phase. These events are expected lead to hypernovae and long duration Gamma-Ray Bursts. Such investigations are still under way. The recent observations of electromagnetic counterparts of short duration Gamma-Ray Bursts and the detection of gravitational waves from compact binary mergers made us shift gears in that direction. We were highly successful in neutron star merger simulations, causing short duration Gamma-Ray Bursts, strong gravitational wave emission and the ejection of the

heaviest elements.

Overall assessment of the achievements and success of the project

The information provided in this section will only be available to ERC staff, to members of the ERC panels, and to the Scientific Council

To what extent have you achieved your objectives?

(i) We could provide most advanced sets of the required input micro physics in terms of the equation of state (EoS) of high density and high temperature matter, large scale nuclear reaction data for energy generation and nucleosynthesis, as well as neutrino matter interactions and collective neutrino oscillations.

(ii) Neutrino transport, being of eminent importance for the simulations, and very time-consuming for multi-D efforts when solving the Boltzmann transport equation, could be treated with a highly efficient approach, the Isotropic Diffusion Source Approximation (IDSA)

(iii) We could provide our own core-collapse stellar progenitor models over a large range of initial stellar masses, utilizing the advanced stellar evolution code MESA.

(iv) 1D core-collapse simulations, based in the “PUSH” method of neutrino heating, which mimics the effect of a multi-D neutrino transport, in order to reproduce observations of explosion energies and ^{56}Ni ejecta, have been performed over an extended range of initial stellar masses. A dependence on the “compactness” parameter before core collapse could be established and the sequence from regular supernovae, over faint supernovae and black hole formation established. As 1D models do not include rotation and magnetic field, only the regular and faint supernova branch but not the hypernova branch could be predicted this way.

(v) Multi-D simulations have been performed for the same mass range in 2D and 3D, testing also EoS properties, rotation and magnetic fields. For non-rotating models this agrees essentially with (iv). A special class of models with high rotation rates and magnetic fields, leading to polar jets, remaining central neutron stars with extremely high magnetic fields (magnetars), and the ejection of very heavy elements in nucleosynthesis studies, have been undertaken with varying ratios between neutrino heating and MHD effects.

(vi) For full scale hypernova (long-duration GRB) simulations, leading to black hole formation plus jet ejecta in case of rotating models with magnetic fields, we would have needed more computing resources and a full five year duration of the grant. This was unfortunately restricted to four years because of my upcoming retirement.

(vii) Instead, motivated by electromagnetic counterparts of short-duration GRBs and the detection of gravitational waves from compact binary mergers, we focused on neutron star mergers and the nucleosynthesis in their ejecta, from very heavy elements in the dynamical ejecta, over elements with mass numbers below $A=130$ in neutrino winds in polar opening angles.

(viii) The results of all above items entered in dust formation predictions and the application to galactic evolution, which helped to identify the two rare events of (v) MHD supernovae and (vii) neutron star mergers as the only sites to produce most of the heavy elements, and all those with mass numbers beyond $A=208$.

Summarizing, we achieved almost all initially envisioned objectives, except of (vi), but delivered instead results on a very timely subject (vii). However, research efforts on (vi) are also ongoing beyond the present grant duration.

What are the most important conclusions of your research?

(1) The equation of state (EoS) for high-density and high-temperature matter is crucial for the core-collapse of massive stars as well as binary compact mergers. There exist EoS parameters of the hadron-quark phase transition which fulfill the observational constraints of 2 Msol neutron stars, and lead to a second collapse of a proto-neutron star, when this phase transition takes place. The second

collapse can lead to successful explosions if the neutrino heating mechanism did not lead to successful explosions before this.

(2) In 1D spherically symmetric core collapse simulations we could reproduce the existing observations on explosion energies, ejected ^{56}Ni masses, and neutron star masses, which mark the transition from regular supernovae, over faint supernovae, to the formation of black holes. The extended set of stellar explosion models has provided preliminary results on the nucleosynthesis yields over the initial mass distribution of massive stars, which can now be applied to galactic evolution models. The full and extended analysis of these yields is almost ready for submission.

(3) In multi-D simulations for fast rotation and high magnetic fields we could establish jet-like explosions with an ejecta nucleosynthesis composition, including the heavy r-process elements, and the formation of a neutron star with extremely high magnetic fields (magnetar).

(4) Our earlier investigations on nucleosynthesis ejecta in neutron star mergers could be extended to a large range of neutron star masses and mass ratios, causing a very robust r-process abundance pattern. Problems with the position of the third r-process peak, caused by nuclear fission (the fragment distribution and released fission neutrons) can be overcome with improved (and shorter) beta-decay half-lives of heavy elements far from nuclear stability.

(5) Collective neutrino flavor oscillations in (4) can be highly important and have predominantly an effect on the second phase of a polar neutrino wind (after the dynamical ejecta of 4 in neutron star mergers).

(6) Inhomogeneous galactic “chemical” evolution calculations could establish the importance of (3) and (4/5) as unique and rare sites, being the only important ones for the production of the heavy r-process elements.

To what extent have you gone beyond the state of the art?

All investigations mentioned in the previous section, i.e. points (1) through (6) represent forefront research which is highly cited and has moved forward / defined the state of the art.

What is the impact of the project (within the scientific community and on society)?

Due to the fact that the new results above are exciting and forefront research, they led to many invited presentations and moved the research field forward in a number of directions. This can also be measured by the success rate in the careers of involved young researchers: Kuo-Chuan Pan – position at MSU, Takami Kuroda – position at TU Darmstadt, Matthias Hempel has to decide between Frankfurt and Paris, PhD student Benjamin Wehmeyer – postdoc in North Carolina, Maik Frensel declined an offer from Paris, Oliver Heinemann has to decide whether he accepts an offer from Tokyo. Related, but not ERC-financed PhD students Marius Eichler and Kevin Ebinger have positions at TU/GSI Darmstadt and North Carolina. Master student Etienne Kaiser has been accepted for a PhD position in Keele.

What is the effect on society? Dependent on the fact whether the above mentioned PhDs will lead to accepting scientific positions or entering the industrial workforce, they have in all cases learned how to tackle complicated questions and overcome problems by a combination of intuition, creativity, and hard work. They will be role models for others. The close relation to high performance computing efforts via the Swiss PASC grant and collaborations among Basel, Geneva, and Zurich have made available advanced methods for the whole scientific high performance computing community. In addition, the scientific results related to questions of astrophysical explosions and how all chemical elements in the Universe have been created finds a high interest among the public. Our outreach events have attracted audiences of more than 200. We think explaining and understanding astrophysical objects which essentially led to the emergence of life (by creating the necessary chemical elements) is an important service to society.

How effectively has the project helped you start or consolidate your research group? (for Starting Grants/Consolidators Grants only)

n/a

How well have you been supported by your Host Institution?

working space, local computing, no fees for our own computer cluster (!), library and administrative support for all ERC team members, unfortunately no initial support for a five year grant duration due to upcoming retirement, essential amounts of CPU hour support by the Swiss Supercomputer Center (CSCS) in Lugano, without which this project would not have been possible, plus the additional salary support for personnel involved in related scientific computing (PASC scientific computing grant).

What difference did the ERC make?

It permitted to provide an environment where a large scale of problems from nuclear/particle physics, over stellar objects, to the evolution of galaxies and the cosmos could be addressed like in a strongly connected “production pipeline”. This would have otherwise not have been possible because only singular aspects could have been addressed.

How many people completed a PhD in the framework of the project?	3
Comments:	there have been 2 further PhD projects in related subjects with strong interaction within the extended research group
How many people started a PhD in the framework of the project?	3
Comments:	see above, 2 additional PhDs

List of free Keywords

supernovae, faint supernovae, hypernovae, short and long-duration gamma-ray bursts, neutron star mergers, nuclear equation of state, nuclear reactions, neutrino transport, nucleosynthesis, chemical evolution of galaxies

Annex: Project output records

A1. Publications

LIST OF SCIENTIFIC PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES												
No.	Title / DOI	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Date of publication	Relevant pages	Does the article acknowledge ERC funding?	Is open access provided to this publication?	Type	URL
1	Derivation of the Isotropic Diffusion Source Approximation (IDSA) for Supernova Neutrino Transport by Asymptotic Expansions 10.1137/12089 243X	H. Berninger , E. Frýnod , M. Gander , M. Liebendýrfer , J. Michaud	SIAM Journal on Mathematical Analysis	Vol. 45/Issue 6	Society for Industrial and Applied Mathematics Publications	United States	01/01/2013	3229- 3265	No	Yes	Peer reviewed	http://epubs.siam.org/doi/abs/10.1137/12089243X
2	Neutrino-driven wind simulations and nucleosynthesis of heavy elements 10.1088/0954- 3899/40/1/013201	A Arcones , F-K Thielemann	Journal of Physics G: Nuclear and Particle Physics	Vol. 40/Issue 1	Institute of Physics Publishing	United Kingdom	01/01/2013	013201	No	Yes	Peer reviewed	http://stacks.iop.org/0954-3899/40/i=1/a=013201?key=crossref.72412437c70b0c54ca f0da5d bd94da36
3	Probabilities of delayed processes for nuclei involved in the r-process 10.1134/S1063 778813010080	I. V. Panov , I. Yu. Korneev , Yu. S. Lutostansky , F. -K. Thielemann	Physics of Atomic Nuclei	Vol. 76/Issue 1	Maik Nauka-Interperi odica Publishing	Russian Federation	01/01/2013	88-101	No	Yes	Peer reviewed	http://link.springer.com/10.1134/S1063778813010080
4	ON THE IMPORTANCE OF THE EQUATION OF STATE FOR THE NEUTRINO-DRIVEN SUPERNOVA EXPLOSION MECHANISM 10.1088/0004-6 37X/764/1/99	Suwa, Yudai; Takiwaki, Tomoya; Kotake, Kei; Fischer, Tobias; Liebendörfer, Matthias; Sato,	Astrophysical Journal	764	Institute of Physics Publishing		01/02/2013	99	No	Yes	Peer reviewed	

		Katsuhiko										
5	Influence of spontaneous fission rates on the yields of superheavy elements in the r-process 10.1134/S1063 773713030043	I. V. Panov , I. Yu. Korneev , G. Martinez-Pinedo , F. -K. Thielemann	Astronomy Letters	Vol. 39/Issue 3	Maik Nauka-Interperi odica Publishing	Russian Federation	01/03/2013	150-160	No	Yes	Peer reviewed	http://link.springer.com/10.1134/S1063773713030043
6	The internal structure of neutron stars and white dwarfs, and the Jacobi virial equation. II. 10.1051/0004-6361/201220565	A. Claret , M. Hempel	Astronomy and Astrophysics	Vol. 552	EDP Sciences	France	01/04/2013	A29	No	Yes	Peer reviewed	http://www.aanda.org/10.1051/0004-6361/201220565
7	Abundances of neutron-capture elements in stars of the Galactic disk substructures 10.1051/0004-6361/201220687	T. V. Mishenina , M. Pignatari , S. A. Korotin , C. Soubiran , C. Charbonnel , F.-K. Thielemann , T. I. Gorbaneva , N. Yu. Basak	Astronomy and Astrophysics	Vol. 552	EDP Sciences	France	01/04/2013	A128	No	Yes	Peer reviewed	http://www.aanda.org/10.1051/0004-6361/201220687
8	Making the Elements in the Universe 10.1051/e pn/2013304	Karlheinz Langanke , Friedrich-Karl Thielemann	Europhysics News	Vol. 44/Issue 3	EDP Sciences	France	01/05/2013	23-26	No	No	Peer reviewed	http://www.europhysicsnews.org/10.1051/e pn/2013304
9	Systematic study of (p,γ) reactions on Ni isotopes 10.1103/PhysRevC.87.055802	A. Simon , A. Spyrou , T. Rauscher , C. Fröhlich , S. J. Quinn , A. Battaglia , A. Best , B. Bucher , M. Couder , P. A. DeYoung , X. Fang , J. Gýrres , A. Kontos , Q. Li , L.-Y. Lin , A. Long , S. Lyons , A. Roberts , D. Robertson , K.	Physical Review C - Nuclear Physics	Vol. 87/Issue 5	American Physical Society	United States	01/05/2013	055802	No	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevC.87.055802

		Smith , M. K. Smith , E. Stech , B. Stefanek , W. P. Tan , X. D. Tang , M. Wiescher										
10	The s-process in the Galactic halo: the fifth signature of spinstars in the early Universe? 10.1051/0004- 6361/201220809	G. Cescutti , C. Chiappini , R. Hirschi , G. Meynet , U. Frischknecht	Astronomy and Astrophysics	Vol. 553	EDP Sciences	France	01/05/2013	A51	Yes	Yes	Peer reviewed	http://www.aanda.org/10.1051/0004-6361/201220809
11	Constraining the astrophysical origin of the p-nuclei through nuclear physics and meteoritic data 10.1088/0034- 4885/76/6/066201	T Rauscher , N Dauphas , I Dillmann , C Frýhlich , Zs Fýlýp , Gy Gyýrky	Reports on Progress in Physics	Vol. 76/Issue 6	Institute of Physics Publishing	United Kingdom	01/06/2013	066201	Yes	Yes	Peer reviewed	http://stacks.iop.org/0034-4885/76/i=6/a=066201?key=crossref.19709d5f71b8a4d4dbf240bcab6edfdc
12	A comparative study of statistical models for nuclear equation of state of stellar matter 10.1016/j.nuc lphysa.2013.03.010	N. Buyukcizmeci , A.S. Botvina , I.N. Mishustin , R. Ogul , M. Hempel , J. Schaffner-Bielich , F.-K. Thielemann , S. Furusawa , K. Sumiyoshi , S. Yamada , H. Suzuki	Nuclear Physics A	Vol. 907	Elsevier	Netherlands	01/06/2013	13-54	No	Yes	Peer reviewed	http://linkinghub.elsevier.com/retrieve/pii/S0375947413003588
13	SILICON CARBIDE GRAINS OF TYPE C PROVIDE EVIDENCE FOR THE PRODUCTION OF THE UNSTABLE ISOTOPE 10.1088/2041-8 205/771/1/L7	M. Pignatari , E. Zinner , M. G. Bertolli , R. Trappitsch , P. Hoppe , T. Rauscher , C. Fryer , F. Herwig , R. Hirschi , F. X. Timmes , F.-K. Thielemann	Astrophysical Journal Letters	Vol. 771/Issue 1	Institute of Physics Publishing	United Kingdom	01/07/2013	L7	Yes	Yes	Peer reviewed	http://stacks.iop.org/2041-8205/771/i=1/a=L7?key=crossref.88a7451bf1637b26b5a76607edc11ad2

14	Noncongruence of the nuclear liquid-gas and deconfinement phase transitions 10.1103/PhysRevC.88.014906	Matthias Hempel , Veronica Dexheimer , Stefan Schramm , Igor Iosilevskiy	Physical Review C - Nuclear Physics	Vol. 88/Issue 1	American Physical Society	United States	01/07/2013	014906	No	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevC.88.014906
15	Solution of the Gamma-Potential Mystery in the Gamma Process and Its Impact on the Nd/Sm Ratio in Meteorites 10.1103/PhysRevLett.111.061104	Thomas Rauscher	Physical Review Letters	Vol. 111/Issue 6	American Physical Society	United States	01/08/2013	061104	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevLett.111.061104
16	Evolution and fate of very massive stars 10.1093/mnras/stt794	N. Yusof , R. Hirschi , G. Meynet , P. A. Crowther , S. Ekstrom , U. Frischknecht , C. Georgy , H. Abu Kassim , O. Schnurr	Monthly Notices of the Royal Astronomical Society	Vol. 433/Issue 2	Blackwell Publishing	United Kingdom	01/08/2013	1114-1132	Yes		Peer reviewed	http://mnras.oxfordjournals.org/cgi/doi/10.1093/mnras/stt794
17	CORE-COLLAPSE SUPERNOVA EQUATIONS OF STATE BASED ON NEUTRON STAR OBSERVATIONS 10.1088/0004-637X/774/1/17	A. W. Steiner , M. Hempel , T. Fischer	Astrophysical Journal	Vol. 774/Issue 1	Institute of Physics Publishing	United Kingdom	01/09/2013	17	No	Yes	Peer reviewed	http://stacks.iop.org/0004-637X/774/i=1/a=17?key=crossref.d25a353dc7795efb959702ce35ca8a6a
18	Suppression of excited-state contributions to stellar reaction rates 10.1103/PhysRevC.88.035803	T. Rauscher	Physical Review C - Nuclear Physics	Vol. 88/Issue 3	American Physical Society	United States	01/09/2013	035803	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevC.88.035803
19	Nuclear masses and neutron stars 10.1016/j.ijms.2013.02.015	S. Kreim , M. Hempel , D. Lunney , J. Schaffner-Bielich	International Journal of Mass Spectrometry	Vol. 349-350	Elsevier	Netherlands	01/09/2013	63-68	No	Yes	Peer reviewed	http://linkinghub.elsevier.com/retrieve/pii/S1387380613000766
20	High precision $\{113\}In(\gamma,\gamma)\{113\}In$ elastic scattering at energies near the Coulomb barrier for the astrophysical gamma process 10.1103/PhysRevC.88.045804	G. G. Kiss , P. Mohr , Zs. Fýlyp , T. Rauscher , Gy. Gyýrky , T. Szýcs , Z. Halýsz , E.	Physical Review C - Nuclear Physics	Vol. 88/Issue 4	American Physical Society	United States	01/10/2013	045804	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevC.88.045804

		Somorjai , A. Ornelas , C. Yalýln , R. T. Gýray , N. ýzkan											
21	Symmetry energy impact in simulations of core-collapse supernovae 10.1140/epja/i 2014-14046-5	Tobias Fischer , Matthias Hempel , Irina Sagert , Yudai Suwa , Jýrgen Schaffner-Bielich	European Physical Journal A	Vol. 50/Issue 2	Springer New York	United States	01/02/2014	46	No	Yes	Peer reviewe	http://link.springer.com/10.1140/epja/i2014-14046-5	
22	Gravitational wave signatures from low-mode spiral instabilities in rapidly rotating supernova cores 10.1103/PhysRevD.89.044011	Takami Kuroda , Tomoya Takiwaki , Kei Kotake	Physical Review D - Particles, Fields, Gravitation and Cosmology	Vol. 89/Issue 4	American Physical Society	United States	01/02/2014	044011	Yes	Yes	Peer reviewe	http://link.aps.org/doi/10.1103/PhysRevD.89.044011	
23	The long-term evolution of neutron star merger remnants - I. The impact of r-process nucleosynthesis 10.1093/mnras/stt2502	S. Rosswog , O. Korobkin , A. Arcones , F.- K. Thielemann , T. Piran	Monthly Notices of the Royal Astronomical Society	Vol. 439/Issue 1	Blackwell Publishing	United Kingdom	21/03/2014	744-756	Yes	Yes	Peer reviewe	http://mnras.oxfordjournals.org/cgi/doi/10.1093/mnras/stt2502	
24	Challenges in nucleosynthesis of trans-iron elements 10.1063/1.4868 239	T. Rauscher	AIP Advances	Vol. 4/Issue 4	AIP	United States	01/04/2014	041012	Yes	Yes	Peer reviewe	http://scitation.aip.org/content/aip/journal/adv/4/4/10.1063/1.4868239	
25	Measurement of the $^{58}\text{Ni}(\alpha,\gamma)^{62}\text{Zn}$ reaction and its astrophysical impact 10.1103/PhysRevC.89.054611	S. J. Quinn , A. Spyrou , E. Bravo , T. Rauscher , A. Simon , A. Battaglia , M. Bowers , B. Bucher , C. Casarella , M. Couder , P. A. DeYoung , A. C. Dombos , J. Gýrres , A. Kontos , Q. Li , A. Long , M. Moran , N. Paul , J.	Physical Review C - Nuclear Physics	Vol. 89/Issue 5	American Physical Society	United States	01/05/2014	054611	Yes	Yes	Peer reviewe	http://link.aps.org/doi/10.1103/PhysRevC.89.054611	

		Pereira , D. Robertson , K. Smith , M. K. Smith , E. Stech , R. Talwar , W. P. Tan , M. Wiescher										
26	Neutron Capture Reactions on Fe and Ni Isotopes for the Astrophysical s-process 10.1016/j.nds.2014.07.046	Lederer, C. et al.	Nuclear Data Sheets	120	Academic Press Inc.		01/06/2014	201-204	Yes	Yes	Peer reviewed	
27	Experimental cross sections of Ho165(alpha,n)Tm168 and Er166(alpha,n)Yb169 for optical potential studies relevant for the astrophysical gamma-process 10.1103/PhysRevC.89.065808	J. Glorius , K. Sonnabend , J. Görres , D. Robertson , M. Knörzer , A. Kontos , T. Rauscher , R. Reifarh , A. Sauerwein , E. Stech , W. Tan , T. Thomas , M. Wiescher	Physical Review C - Nuclear Physics	Vol. 89/Issue 6	American Physical Society	United States	01/06/2014	065808	Yes	No	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevC.89.065808
28	Alpha induced reaction cross section measurements on 162Er for the astrophysical gamma process 10.1016/j.physletb.2014.06.011	G.G. Kiss , T. Szycs , T. Rauscher , Zs. Týryk , Zs. Fýlyp , Gy. Gyýrky , Z. Halýsz , E. Somorjai	Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics	Vol. 735	Elsevier	Netherlands	01/07/2014	40-44	Yes	Yes	Peer reviewed	http://linkinghub.elsevier.com/retrieve/pii/S0370269314004067
29	MODA: a new algorithm to compute optical depths in multidimensional hydrodynamic simulations 10.1051/0004-6361/201423755	Albino Perego , Emanuel Gafon , Rubýn Cabezýn , Stephan Rosswog , Matthias Liebendýrfer	Astronomy and Astrophysics	Vol. 568	EDP Sciences	France	01/08/2014	A11	Yes	Yes	Peer reviewed	http://www.aanda.org/10.1051/0004-6361/201423755
30	Cross-section measurement of the Ba130(p,gamma)La131 reaction for	L. Netterdon , A. Endres , G.	Physical Review C - Nuclear Physics	Vol. 90/Issue 3	American Physical Society	United States	01/09/2014	035806	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevC

	gamma-process nucleosynthesis 10.1103/PhysRevC.90.035806	G. Kiss , J. Mayer , T. Rauscher , P. Scholz , K. Sonnabend , Zs. Török , A. Zilges											.90.035806
31	SEARCH FOR SURVIVING COMPANIONS IN TYPE Ia SUPERNOVA REMNANTS 10.1088/0004-637X/792/1/71	Kuo-Chuan Pan , Paul M. Ricker , Ronald E. Taam	Astrophysical Journal	Vol. 792/Issue 1	Institute of Physics Publishing	United Kingdom	01/09/2014	71	Yes	Yes	Peer review	http://stacks.iop.org/0004-637X/792/i=1/a=71?key=crossref.933a014e1ac3cf2f3c3f5d95dc9de149	
32	Asymmetric neutrino production in strongly magnetized proto-neutron stars 10.1103/PhysRevD.90.067302	Tomoyuki Maruyama , Myung-Ki Cheoun , Jun Hidaka , Toshitaka Kajino , Takami Kuroda , Grant J. Mathews , Chung-Yeol Ryu , Tomoya Takiwaki , Nobutoshi Yasutake	Physical Review D - Particles, Fields, Gravitation and Cosmology	Vol. 90/Issue 6	American Physical Society	United States	01/09/2014	067302	Yes	Yes	Peer review	http://link.aps.org/doi/10.1103/PhysRevD.90.067302	
33	IMPACTS OF ROTATION ON THREE-DIMENSIONAL HYDRODYNAMICS OF CORE-COLLAPSE SUPERNOVAE 10.1088/0004-637X/793/1/45	Ko Nakamura , Takami Kuroda , Tomoya Takiwaki , Kei Kotake	Astrophysical Journal	Vol. 793/Issue 1	Institute of Physics Publishing	United Kingdom	20/09/2014	45	Yes	Yes	Peer review	http://stacks.iop.org/0004-637X/793/i=1/a=45?key=crossref.e9e97928d3dd8321c429b b756dedd946	
34	NEW HYPERON EQUATIONS OF STATE FOR SUPERNOVAE AND NEUTRON STARS IN DENSITY-DEPENDENT HADRON FIELD THEORY 10.1088/0067-0049/214/2/22	Sarmistha Banik , Matthias Hempel , Debades Bandyopadhyay	Astrophysical Journal, Supplement Series	Vol. 214/Issue 2	Institute of Physics Publishing	United Kingdom	01/10/2014	22	No	Yes	Peer review	http://stacks.iop.org/0067-0049/214/i=2/a=22?key=crossref.f436eaa24de3f3a3bd62 661e2daa812	
35	Equalizing resolution in smoothed-particle hydrodynamics calculations using self-adaptive sinc kernels	Domingo Garc3ya-Senz , Rub3yn M. Cabez3yn ,	Astronomy and Astrophysics	Vol. 570	EDP Sciences	France	01/10/2014	A14	Yes	Yes	Peer review	http://www.aanda.org/10.1051/0004-6361/201424260	

	10.1051/0004-6 361/201424260	Josý A. Escartýn , Kevin Ebinger										
36	Neutrino-driven winds from neutron star merger remnants 10.1093/mnras/ stu1352	A. Perego , S. Rosswog , R. M. Cabezon , O. Korobkin , R. Kappeli , A. Arcones , M. Liebendorfer	Monthly Notices of the Royal Astronomical Society	Vol. 443/Issue 4	Blackwell Publishing	United Kingdom	01/10/2014	3134-3156	Yes	Yes	Peer reviewe	http://mnras.oxfordjournals.org/cgi/doi/10.1093/mnras/stu1352
37	Radiogenic p-isotopes from Type Ia Supernova, Nuclear Physics Uncertainties, and Galactic Chemical Evolution Compared with Values in Primitive Meteorites 10.1088/0004-6 37X/795/2/141	C. Travaglio , R. Gallino , T. Rauscher , N. Dauphas , F. K. Rýpke , W. Hillebrandt	Astrophysical Journal	Vol. 795/Issue 2	Institute of Physics Publishing	United Kingdom	10/11/2014	141	Yes	Yes	Peer reviewe	http://stacks.iop.org/0004-637X/795/i=2/a=141?key=crossref.0ff47a9dd6ad31c72357d47fd4741eb5
38	TESTING THE ROLE OF SNe Ia FOR GALACTIC CHEMICAL EVOLUTION OF 10.1088/0004-6 37X/799/1/54	C. Travaglio , R. Gallino , T. Rauscher , F. K. Rýpke , W. Hillebrandt	Astrophysical Journal	Vol. 799/Issue 1	Institute of Physics Publishing	United Kingdom	20/01/2015	54	Yes	Yes	Peer reviewe	http://stacks.iop.org/0004-637X/799/i=1/a=54?key=crossref.89a34c294938de45612307d02ba3b123
39	Test of statistical model cross section calculations for alpha-induced reactions on Ag 107 at energies of astrophysical interest 10.1103/PhysRe vC.91.034610	C. Yalç#n , Gy. Gyürky , T. Rauscher , G. G. Kiss , N. Özkan , R. T. Güray , Z. Halász , T. Szüics , Zs. Fülöp , J. Farkas , Z. Korkulu , E. Somorjai	Physical Review C - Nuclear Physics	Vol. 91/Issue 3	American Physical Society	United States	01/03/2015	034610	Yes	Yes	Peer reviewe	http://link.aps.org/doi/10.1103/PhysRevC.91.034610
40	Measurements of 152Gd .. cross sections for the astrophysical p-process 10.1103/PhysR evC.91.055809	R. T. Güray , N. Özkan , C. Yalç#n , T. Rauscher , Gy. Gyürky , J. Farkas , Zs. Fülöp , Z. Halász , E. Somorjai	Physical Review C - Nuclear Physics	Vol. 91/Issue 5	American Physical Society	United States	01/05/2015	055809	Yes	Yes	Peer reviewe	http://link.aps.org/doi/10.1103/PhysRevC.91.055809

41	Measurement of (σ , n) reaction cross sections of erbium isotopes for testing astrophysical rate predictions 10.1088/0954-3899/42/5/055103	G G Kiss , T Szűcs , T Rauscher , Zs Török , L Csedreki , Zs Fülöp , Gy Gyürky , Z Halász	Journal of Physics G: Nuclear and Particle Physics	Vol. 42/Issue 5	Institute of Physics Publishing	United Kingdom	01/05/2015	055103	Yes	Yes	Peer reviewed	http://stacks.iop.org/0954-3899/42/i=5/a=055103?key=crossref.a38d1b58bd7792e6a1289be91b91d8f7
42	SIMULATIONS OF THE SYMBIOTIC RECURRENT NOVA V407 CYG. I. ACCRETION AND SHOCK EVOLUTIONS 10.1088/0004-637X/806/1/27	Kuo-Chuan Pan (###) , Paul M. Ricker , Ronald E. Taam	Astrophysical Journal	Vol. 806/Issue 1	Institute of Physics Publishing	United Kingdom	10/06/2015	27	Yes	Yes	Peer reviewed	http://stacks.iop.org/0004-637X/806/i=1/a=27?key=crossref.eb5bf12e2cb546fd8e591d00173521fa
43	PUSHING CORE-COLLAPSE SUPERNOVAE TO EXPLOSIONS IN SPHERICAL SYMMETRY. I. THE MODEL AND THE CASE OF SN 1987A 10.1088/0004-637X/806/2/275	A. Perego , M. Hempel , C. Fröhlich , K. Ebinger , M. Eichler , J. Casanova , M. Liebendörfer , F.-K. Thielemann	Astrophysical Journal	Vol. 806/Issue 2	Institute of Physics Publishing	United Kingdom	20/06/2015	275	Yes	Yes	Peer reviewed	http://stacks.iop.org/0004-637X/806/i=2/a=275?key=crossref.cb6338b0fc5bc227cdd566733fd6ae2d
44	THE ROLE OF FISSION IN NEUTRON STAR MERGERS AND ITS IMPACT ON THE r -PROCESS PEAKS 10.1088/0004-637X/808/1/30	M. Eichler , A. Arcones , A. Kelic , O. Korobkin , K. Langanke , T. Marketin , G. Martinez-Pinedo , I. Panov , T. Rauscher , S. Rosswog , C. Winteler , N. T. Zinner , F.-K. Thielemann	Astrophysical Journal	Vol. 808/Issue 1	Institute of Physics Publishing	United Kingdom	20/07/2015	30	Yes	Yes	Peer reviewed	http://stacks.iop.org/0004-637X/808/i=1/a=30?key=crossref.1fc5ffda1a65067dc1c0263d4bc3e8fd
45	The $^{106}\text{Cd}(\#, \#)^{106}\text{Cd}$ elastic scattering in a wide energy range for $\#$ process studies 10.1016/j.nuclphysa.2015.04.008	A. Ornelas , G.G. Kiss , P. Mohr , D. Galaviz , Zs. Fülöp , Gy. Gyürky , Z. Máté , T. Rauscher , E.	Nuclear Physics A	Vol. 940	Elsevier	Netherlands	01/08/2015	194-209	Yes	Yes	Peer reviewed	http://linkinghub.elsevier.com/retrieve/pii/S0375947415001049

		Somorjai , K. Sonnabend , A. Zilges										
46	THE r -PROCESS NUCLEOSYNTHESIS IN THE VARIOUS JET-LIKE EXPLOSIONS OF MAGNETOROTATIONAL CORE-COLLAPSE SUPERNOVAE 10.1088/0004-637X/810/2/109	Nobuya Nishimura , Tomoya Takiwaki , Friedrich-Karl Thielemann	Astrophysical Journal	Vol. 810/Issue 2	Institute of Physics Publishing	United Kingdom	10/09/2015	109	Yes	Yes	Peer reviewed	http://stacks.iop.org/0004-637X/810/i=2/a=109?key=crossref.d77d4996f1908d76408eff58edbe74d1
47	Galactic evolution of rapid neutron capture process abundances: the inhomogeneous approach 10.1093/mnras/stv1352	B. Wehmeyer , M. Pignatari , F.-K. Thielemann	Monthly Notices of the Royal Astronomical Society	Vol. 452/Issue 2	Blackwell Publishing	United Kingdom	11/09/2015	1970- 1981	Yes	Yes	Peer reviewed	https://academic.oup.com/mnras/article-lookup/doi/10.1093/mnras/stv1352
48	THREE-DIMENSIONAL SIMULATION OF A ROTATING CORE-COLLAPSE SUPERNOVA 10.5303/PKAS.2015.30.2.481	KO NAKAMURA , TAKAMI KURODA , TOMOYA TAKIWAKI , KEI KOTAKE	Journal of the Korean Astronomical Society	Vol. 30/Issue 2	Korean Astronomical Society		30/09/2015	481-483	Yes	Yes	Peer reviewed	http://koreascience.or.kr/journal/view.jsp?kj=CMHHCI&py=2015&vnc=v30n2&sp=481
49	NEUTRINO-DRIVEN WINDS IN THE AFTERMATH OF A NEUTRON STAR MERGER: NUCLEOSYNTHESIS AND ELECTROMAGNETIC TRANSIENTS 10.1088/0004-637X/813/1/2	D. Martin , A. Perego , A. Arcones , F.-K. Thielemann , O. Korobkin , S. Rosswog	Astrophysical Journal	Vol. 813/Issue 1	Institute of Physics Publishing	United Kingdom	01/11/2015	2	Yes	Yes	Peer reviewed	http://stacks.iop.org/0004-637X/813/i=1/a=2?key=crossref.7997dba47be0a82cc556627887825d77
50	Coherent network analysis of gravitational waves from three-dimensional core-collapse supernova models 10.1103/PhysRevD.92.122001	Kazuhiro Hayama , Takami Kuroda , Kei Kotake , Tomoya Takiwaki	Physical Review D - Particles, Fields, Gravitation and Cosmology	Vol. 92/Issue 12	American Physical Society	United States	01/12/2015	122001	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevD.92.122001
51	Nuclear astrophysics: Deep-sea diving for stellar debris 10.1038/nphys3591	Friedrich-Karl Thielemann	Nature Physics	Vol. 11/Issue 12	Nature Publishing Group	United Kingdom	01/12/2015	993-994	No	Yes	Peer reviewed	http://www.nature.com/doi/10.1038/nphys3591
52	Mn abundances in the stars of the Galactic disc with metallicities #1.0 <	T. Mishenina , T. Gorbaneva	Monthly Notices of the Royal Astronomical Society	Vol. 454/Issue	Blackwell Publishing	United Kingdom	01/12/2015	1585- 1594	Yes	Yes	Peer reviewed	http://mnras.oxfordjournals.org/lookup/d

	[Fe/H] < 0.3 10.1093/mnras/ stv2038	, M. Pignatari , F.-K. Thielemann , S. A. Korotin		2								oi/10.1093/mnras/stv2038
53	Systematic features of axisymmetric neutrino-driven core-collapse supernova models in multiple progenitors 10.1093/pasj/ psv073	Ko Nakamura , Tomoya Takiwaki , Takami Kuroda , Kei Kotake	Publication of the Astronomical Society of Japan	Vol. 67/Issue 6	Astronomical Society of Japan	Japan	04/12/2015	107	Yes	Yes	Peer reviewed	http://pasj.oxfordjournals.org/lookup/doi/10.1093/pasj/psv073
54	Dust formation in the oxygen-rich AGB star IK Tauri 10.1051/0004- 6361/201425363	D. Gobrecht , I. Cherchneff , A. Sarangi , J. M. C. Plane , S. T. Bromley	Astronomy and Astrophysics	Vol. 585	EDP Sciences	France	01/01/2016	A6	Yes	Yes	Peer reviewed	http://www.aanda.org/10.1051/0004-6361/201425363
55	Expected impact from weak reactions with light nuclei in core-collapse supernova simulations 10.1051/epjconf/201610906002	T. Fischer , G. Martínez-Pinedo , M. Hempel , L. Huther , G. Röpke , S. Typel , A. Lohs	EPJ Web of Conferences	Vol. 109	EDP Sciences	France	01/01/2016	06002	Yes	Yes	Peer reviewed	http://www.epj-conferences.org/10.1051/epjconf/201610906002
56	Beta-delayed fission probabilities of transfermium nuclei, involved in the r-process 10.1088/1742-6596/665/1/012060	I Panov , Yu Lutostansky , F-K Thielemann	Journal of Physics: Conference Series	Vol. 665	Institute of Physics Publishing	United Kingdom	05/01/2016	012060	Yes	Yes	Peer reviewed	http://stacks.iop.org/1742-6596/665/i=1/a=012060?key=crossref.b47b76f17301158087a7a84b537a875e
57	The Impact of Fission on R-Process Calculations 10.1088/1742- 6596/665/1/012054	M Eichler , A Arcones , R Käppeli , O Korobkin , M Liebendörfer , G Martínez-Pinedo , I V Panov , T Rauscher , S Rosswog , F-K Thielemann , C Winteler	Journal of Physics: Conference Series	Vol. 665	Institute of Physics Publishing	United Kingdom	05/01/2016	012054	No	Yes	Peer reviewed	http://stacks.iop.org/1742-6596/665/i=1/a=012054?key=crossref.bd228f23f8b0ff1d253424b134f7f8d3
58	Current hot questions on the s process in AGB stars	M Lugaro , S W Campbell , V D'Orazi , A	Journal of Physics: Conference Series	Vol. 665	Institute of Physics Publishing	United Kingdom	05/01/2016	012021	Yes	Yes	Peer reviewed	http://stacks.iop.org/1742-6596/665/i=1/a=012021?key

	10.1088/1742- 6596/665/1/012021	I Karakas , D A Garcia-Hernandez , R J Stancliffe , G Tagliente , C Iliadis , T Rauscher										=crossref.ce26dc6b73de0f12a801d918dca2c711
59	Experiments with neutron beams for the astrophysical s process 10.1088/1742-65 96/665/1/012020	C Lederer, .. , M Pignatari , .. , T Rauscher , R Reifarh et al.	Journal of Physics: Conference Series	Vol. 665	Institute of Physics Publishing	United Kingdom	05/01/2016	012020	Yes	Yes	Peer reviewed	http://stacks.iop.org/1742-6596/665/i=1/a=012020?key=crossref.55c55750c844181b5168babbf017d3a24
60	Revision of the derivation of stellar rates from experiment and impact on Eu s-process contributions 10.1088/1742- 6596/665/1/012024	T Rauscher	Journal of Physics: Conference Series	Vol. 665	Institute of Physics Publishing	United Kingdom	05/01/2016	012024	Yes	Yes	Peer reviewed	http://stacks.iop.org/1742-6596/665/i=1/a=012024?key=crossref.5fa05d97a0b11872b b4962d b6cbb9205
61	Nuclear astrophysics with radioactive ions at FAIR 10.1088/1742-65 96/665/1/012044	R Reifarh , .. , T Rauscher et al.	Journal of Physics: Conference Series	Vol. 665	Institute of Physics Publishing	United Kingdom	05/01/2016	012044	Yes	Yes	Peer reviewed	http://stacks.iop.org/1742-6596/665/i=1/a=012044?key=crossref.76279e741b2170740413227d8a452ea7
62	Cross section measurements for #-process studies using a LEPS detector 10.1088/1742- 6596/665/1/012041	T Szücs , GG Kiss , T Rauscher , Zs Török , Z Halász , Zs Fülöp , Gy Gyürky , E Somorjai	Journal of Physics: Conference Series	Vol. 665	Institute of Physics Publishing	United Kingdom	05/01/2016	012041	Yes	Yes	Peer reviewed	http://stacks.iop.org/1742-6596/665/i=1/a=012041?key=crossref.842a3c0af313264fecbebd546b4cb75f
63	Investigation of Alpha-Induced Reactions on ¹⁰⁷ Ag at Astrophysical Energies 10.1088/1742- 6596/665/1/012043	C Yalçın , N Özkan , R T Güray , Gy Gyürky , G G Kiss , T Szücs , Z Haiász , Zs Fülöp , J Farkas , E Somorjai , Z Korkulu , T	Journal of Physics: Conference Series	Vol. 665	Institute of Physics Publishing	United Kingdom	05/01/2016	012043	Yes	Yes	Peer reviewed	http://stacks.iop.org/1742-6596/665/i=1/a=012043?key=crossref.1728de88b91a107522165848a46a4c30

		Rauscher										
64	TWO-DIMENSIONAL CORE-COLLAPSE SUPERNOVA SIMULATIONS WITH THE ISOTROPIC DIFFUSION SOURCE APPROXIMATION FOR NEUTRINO TRANSPORT 10.3847/0004-637X/817/1/72	Kuo-Chuan Pan (###) , Matthias Liebendörfer , Matthias Hempel , Friedrich-Karl Thielemann	Astrophysical Journal	Vol. 817/Issue 1	Institute of Physics Publishing	United Kingdom	20/01/2016	72	Yes	Yes	Peer reviewed	http://stacks.iop.org/0004-637X/817/i=1/a=72?key=crossref.c9ced7068ce43c34a9fb3857351d6454
65	A NEW MULTI-ENERGY NEUTRINO RADIATION-HYDRODYNAMICS CODE IN FULL GENERAL RELATIVITY AND ITS APPLICATION TO THE GRAVITATIONAL COLLAPSE OF MASSIVE STARS 10.3847/0067-0049/222/2/20	Takami Kuroda , Tomoya Takiwaki , Kei Kotake	Astrophysical Journal, Supplement Series	Vol. 222/Issue 2	Institute of Physics Publishing	United Kingdom	01/02/2016	20	Yes	Yes	Peer reviewed	http://stacks.iop.org/0067-0049/222/i=2/a=20?key=crossref.fea932e751e2201c7ef89168dd3f9690
66	Some properties of convection in hybrid stars 10.1093/mnras/stv2614	A. V. Yudin , M. Hempel , D. K. Nadyozhin , T. L. Razinkova	Monthly Notices of the Royal Astronomical Society	Vol. 455/Issue 4	Blackwell Publishing	United Kingdom	01/02/2016	4325-4328	Yes	Yes	Peer reviewed	http://mnras.oxfordjournals.org/lookup/doi/10.1093/mnras/stv2614
67	Hybrid method to resolve the neutrino mass hierarchy by supernova (anti)neutrino induced reactions 10.1088/1475-7516/2016/02/007	D. Vale , T. Rauscher , N. Paar	Journal of Cosmology and Astroparticle Physics	Vol. 2016/Issue 02	Institute of Physics Publishing	United Kingdom	01/02/2016	007-007	Yes	Yes	Peer reviewed	http://stacks.iop.org/1475-7516/2016/i=02/a=007?key=crossref.a84bd23e6b9d6e524fa44fba0699a88e
68	s -process production in rotating massive stars at solar and low metallicities 10.1093/mnras/stv2723	Urs Frischknecht , Raphael Hirschi , Marco Pignatari , André Maeder , George Meynet , Cristina Chiappini , Friedrich-Karl Thielemann , Thomas	Monthly Notices of the Royal Astronomical Society	Vol. 456/Issue 2	Blackwell Publishing	United Kingdom	21/02/2016	1803-1825	Yes	Yes	Peer reviewed	http://mnras.oxfordjournals.org/lookup/doi/10.1093/mnras/stv2723

		Rauscher , Cyril Georgy , Sylvia Ekström											
69	Beta-decay half-lives for the r-process nuclei 10.1016/j.nucl physa.2015.12.0 01	I.V. Panov , Yu.S. Lutostansky , F.-K. Thielemann	Nuclear Physics A	Vol. 947	Elsevier	Netherlands	01/03/2016	1-11	No	Yes	Peer reviewed	http://linkinghub.elsevier.com/retrieve/pii/S0375947415002833	
70	An observational study of dust nucleation in Mira (o Ceti) 10.1051/0004- 6361/201629838	T. Kami#ski , H. S. P. Müller , M. R. Schmidt , I. Cherchneff , K. T. Wong , S. Brünken , K. M. Menten , J. M. Winters , C. A. Gottlieb , N. A. Patel	Astronomy and Astrophysics	Vol. 599	EDP Sciences	France	01/03/2017	A59	Yes	Yes	Peer reviewed	http://www.aanda.org/10.1051/0004-6361/201629838	
71	Neutron-induced fission cross section of Np 237 in the keV to MeV range at the CERN n_TOF facility 10.1103/PhysR evC.93.034614	M. Diakaki ,..., T. Rauscher , R. Reifarth et al.	Physical Review C - Nuclear Physics	Vol. 93/Issue 3	American Physical Society		01/03/2016	034614	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevC.93.034614	
72	TYPE Ia SUPERNOVAE: CAN CORIOLIS FORCE BREAK THE SYMMETRY OF THE GRAVITATIONAL CONFINED DETONATION EXPLOSION MECHANISM? 10.3847/0004-6 37X/819/2/132	D. García-Senz , R. M. Cabezón , I. Domínguez , F. K. Thielemann	Astrophysical Journal	Vol. 819/Issue 2	Institute of Physics Publishing	United Kingdom	10/03/2016	132	Yes	Yes	Peer reviewed	http://stacks.iop.org/0004-637X/819/i=2/a=132?key=crossref.22567ea3ecf9768b111f7b498fa3d59b	
73	Chemistry and distribution of daughter species in the circumstellar envelopes of O-rich AGB stars 10.1051/0004- 6361/201525739	Xiaohu Li , Tom J. Millar , Alan N. Heays , Catherine Walsh , Ewine F. van Dishoeck , Isabelle Cherchneff	Astronomy and Astrophysics	Vol. 588	EDP Sciences	France	01/04/2016	A4	Yes	Yes	Peer reviewed	http://www.aanda.org/10.1051/0004-6361/201525739	

74	AN ADVANCED LEAKAGE SCHEME FOR NEUTRINO TREATMENT IN ASTROPHYSICAL SIMULATIONS 10.3847/0067-0049/223/2/22	A. Perego , R. M. Cabezon , R. Käppeli	Astrophysical Journal, Supplement Series	Vol. 223/Issue 2	Institute of Physics Publishing	United Kingdom	01/04/2016	22	Yes	Yes	Peer reviewed	http://stacks.iop.org/0067-0049/223/i=2/a=22?key=crossref.06953cc851deb1cf6877702f00f7229c
75	Integral measurement of the $^{12}\text{C}(n,p)^{12}\text{B}$ reaction up to 10 GeV 10.1140/epja/i2016-16101-7	P. Žugec , ..., T. Rauscher , R. Reifarth et al.	European Physical Journal A	Vol. 52/Issue 4	Springer New York	United States	01/04/2016	101	Yes	Yes	Peer reviewed	http://link.springer.com/10.1140/epja/i2016-16101-7
76	Molecules and dust in Cassiopeia A 10.1051/0004-6361/201527769	Chiara Biscaro , Isabelle Cherchneff	Astronomy and Astrophysics	Vol. 589	EDP Sciences	France	01/05/2016	A132	Yes	Yes	Peer reviewed	http://www.aanda.org/10.1051/0004-6361/201527769
77	On the origin of the cosmic elements and the nuclear history of the universe 10.1051/eprn/2016401	Jordi José , Martin Asplund , Corinne Charbonel , Isabelle Cherchneff , Roland Diehl , Andreas Korn , Friedrich-Karl Thielemann	Europhysics News	Vol. 47/Issue 4	EDP Sciences	France	01/07/2016	15-20	No	Yes	Peer reviewed	http://www.europhysicsnews.org/10.1051/eprn/2016401
78	An observational study of dust nucleation in Mira (o Ceti) 10.1051/0004-6361/201628664	T. Kamiński , K. T. Wong , M. R. Schmidt , H. S. P. Müller , C. A. Gottlieb , I. Cherchneff , K. M. Menten , D. Keller , S. Brünken , J. M. Winters , N. A. Patel	Astronomy and Astrophysics	Vol. 592	EDP Sciences	France	01/08/2016	A42	Yes	Yes	Peer reviewed	http://www.aanda.org/10.1051/0004-6361/201628664
79	Dust formation in evolved stars and supernovae: new advances and unsolved problems 10.1017/S1743921316004737	Isabelle Cherchneff	Proceedings of the International Astronomical Union	Vol. 11/Issue A29B	Cambridge University Press	United Kingdom	01/08/2015	166-168	Yes	Yes	Peer reviewed	https://www.cambridge.org/core/product/identifier/S1743921316004737/type/journal_article

80	APPLICATION OF A THEORY AND SIMULATION-BASED CONVECTIVE BOUNDARY MIXING MODEL FOR AGB STAR EVOLUTION AND NUCLEOSYNTHESIS 10.3847/0004-637X/827/1/30	U. Battino , M. Pignatari , C. Ritter , F. Herwig , P. Denisenkov , J. W. Den Hartogh , R. Trappitsch , R. Hirschi , B. Freytag , F. Thielemann , B. Paxton	Astrophysical Journal	Vol. 827/Issue 1	Institute of Physics Publishing	United Kingdom	10/08/2016	30	Yes	Yes	Peer reviewed	http://stacks.iop.org/0004-637X/827/i=1/a=30?key=crossref.d189ec70868450dbec8376bbeae91f7
81	Experimental setup and procedure for the measurement of the $7\text{Be}(n,\#)\#$ reaction at n_TOF 10.1016/j.nima.2016.05.089	L. Cosentino , T. Rauscher , R. Reifarh et al.	Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment	Vol. 830	Elsevier	Netherlands	01/09/2016	197-205	Yes	Yes	Peer reviewed	http://linkinghub.elsevier.com/retrieve/pii/S016890021630482X
82	A NEW GRAVITATIONAL-WAVE SIGNATURE FROM STANDING ACCRETION SHOCK INSTABILITY IN SUPERNOVAE 10.3847/2041-8205/829/1/L14	Takami Kuroda , Kei Kotake , Tomoya Takiwaki	Astrophysical Journal Letters	Vol. 829/Issue 1	Institute of Physics Publishing	United Kingdom	20/09/2016	L14	Yes	Yes	Peer reviewed	http://stacks.iop.org/2041-8205/829/i=1/a=L14?key=crossref.02a51f64f78fbef1545a210fd2183fbb
83	$7\text{Be}(n,\alpha)4\text{He}$ Reaction and the Cosmological Lithium Problem: Measurement of the Cross Section in a Wide Energy Range at n_TOF at CERN 10.1103/PhysRevLett.117.152701	M. Barbagallo , A. Mengoni , R. Dressler , D. Schumann , F. Käppeler , N. Colonna , O. Aberle , S. Altstadt , M. Brugger , D. Cano-Ott , R. Cardella , A. Casanovas , S. Cristallo , I. Duran , B. Fernandez-Dominguez , K. Göbel , C. Guerrero , F. Gunsing , C. Lederer , H. Leeb , T. Rauscher et al.	Physical Review Letters	Vol. 117/Issue 15	American Physical Society	United States	01/10/2016	152701	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevLett.117.152701

84	Nuclear data activities at the n_TOF facility at CERN 10.1140/epjp/ i2016-16371-4	F. Gunsing , O. Aberle , T. Rauscher , R. Reifarh et al.	European Physical Journal Plus	Vol. 131/Issue 10	Springer New York	United States	01/10/2016	371	Yes	Yes	Peer reviewed	http://link.springer.com/10.1140/epjp/i2016-16371-4
85	Experimental study of the astrophysical # -process reaction Xe 124 (# , #) Ba 128 10.1103/PhysRev C.94.045801	Z. Halász , E. Somorjai , Gy. Gyürky , Z. Elekes , Zs. Fülöp , T. Szücs , G. G. Kiss , N. T. Szegedi , T. Rauscher , J. Görres , M. Wiescher	Physical Review C - Nuclear Physics	Vol. 94/Issue 4	American Physical Society		01/10/2016	045801	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevC.94.045801
86	Towards generating a new supernova equation of state: A systematic analysis of cold hybrid stars 10.1103/PhysRevD.94.103008	Oliver Heinmann , Matthias Hempel , Friedrich-Karl Thielemann	Physical Review D - Particles, Fields, Gravitation and Cosmology	Vol. 94/Issue 10	American Physical Society		01/11/2016	103008	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevD.94.103008
87	Hot third family of compact stars and the possibility of core-collapse supernova explosions 10.1103/PhysRevD.94.103001	Matthias Hempel , Oliver Heinmann , Andrey Yudin , Igor Iosilevskiy , Matthias Liebendörfer , Friedrich-Karl Thielemann	Physical Review D - Particles, Fields, Gravitation and Cosmology	Vol. 94/Issue 10	American Physical Society		01/11/2016	103001	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevD.94.103001
88	Uncertainties in the production of p nuclei in massive stars obtained from Monte Carlo variations 10.1093/mnras/stw2266	T. Rauscher , N. Nishimura , R. Hirschi , G. Cescutti , A. St. J. Murphy , A. Heger	Monthly Notices of the Royal Astronomical Society	Vol. 463/Issue 4	Blackwell Publishing	United Kingdom	21/12/2016	4153- 4166	Yes	Yes	Peer reviewed	https://academic.oup.com/mnras/article-lookup/doi/10.1093/mnras/stw2266
89	Neutrino flavor evolution in binary neutron star merger remnants 10.1103/PhysRevD.95.023011	Maik Frensel , Meng-Ru Wu , Cristina Volpe , Albino Perego	Physical Review D - Particles, Fields, Gravitation and Cosmology	Vol. 95/Issue 2	American Physical Society		01/01/2017	023011	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/PhysRevD.95.023011

90	Some properties of convection in hybrid stars 10.1093/mnras/stv2614	A. V. Yudin , M. Hempel , D. K. Nadyozhin , T. L. Razinkova	Monthly Notices of the Royal Astronomical Society	Vol. 455/Issue 4	Blackwell Publishing	United Kingdom	01/02/2016	4325-4328	No	Yes	Peer reviewed	https://academic.oup.com/mnras/article-lookup/doi/10.1093/mnras/stv2614
91	Simultaneous Chiral Symmetry Restoration and Deconfinement Consequences for the QCD Phase Diagram 10.3847/1538-4357/836/1/89	Thomas Klähn , Tobias Fischer , Matthias Hempel	Astrophysical Journal	Vol. 836/Issue 1	Institute of Physics Publishing	United Kingdom	10/02/2017	89	Yes	Yes	Peer reviewed	http://stacks.iop.org/0004-637X/836/i=1/a=89?key=crossref.9ab3c385c05eee494a4f6e9fcb648d54
92	Advanced LIGO Constraints on Neutron Star Mergers and r-process Sites 10.3847/1538-4357/aa5c8d	Benoit Côté , Krzysztof Belczynski , Chris L. Fryer , Christian Ritter , Adam Paul , Benjamin Wehmeyer , Brian W. O'Shea	Astrophysical Journal	Vol. 836/Issue 2	Institute of Physics Publishing	United Kingdom	20/02/2017	230	Yes	Yes	Peer reviewed	http://stacks.iop.org/0004-637X/836/i=2/a=230?key=crossref.69df578fa6a6e0d4f5b77c7f49afd7aa
93	Equations of state for supernovae and compact stars 10.1103/RevModPhys.89.015007	M. Oertel , M. Hempel , T. Klähn , S. Typel	Reviews of Modern Physics	Vol. 89/Issue 1	American Physical Society	United States	01/03/2017	015007	Yes	Yes	Peer reviewed	http://link.aps.org/doi/10.1103/RevModPhys.89.015007
94	The Intermediate r-process in Core-collapse Supernovae Driven by the Magneto-rotational Instability 10.3847/2041-8213/aa5dee	N. Nishimura (### , H. Sawai (### , T. Takiwaki (### , S. Yamada (### , F.-K. Thielemann	Astrophysical Journal Letters	Vol. 836/Issue 2	Institute of Physics Publishing	United Kingdom	20/02/2017	L21	Yes	Yes	Peer reviewed	http://stacks.iop.org/2041-8205/836/i=2/a=L21?key=crossref.7a6ba8c3d7b42a84a0b821d640783a0e
	Supernovae and their Nucleosynthesis	Thielemann, F.-K., Liebendoerfer, M.	Encyclopedia of Nuclear Physics and its Applications		Wiley		01/09/2013	475-502	No	No	Article	
	Die Entstehung der Atome - Eine Synthese von Mikro- und Makrokosmos 10.1007/978-3-658-04158-8	Thielemann, F.-K.	Studium generale		Springer Fachmedien Wiesbaden	Wiesbaden	01/01/2014	97-108	No	No	Article	http://link.springer.com/10.1007/978-3-658-04158-8

Cutting-edge issues of core-collapse supernova theory 10.1063/1.4874 078	Kei Kotake , Ko Nakamura , Takami Kuroda , Tomoya Takiwaki	AIP Conference Proceedings, Volume 1594, ORIGIN OF MATTER AND EVOLUTION OF GALAXIES 2013		AIP Publishing LLC		01/01/2014	250-257	No	No	Conference	http://scitation.aip.org/content/aip/proceeding/aipcp/10.1063/1.4874078
Three-dimensional simulation of a rotating supernova 10.1063/1.4874 084	K. Nakamura , T. Kuroda , T. Takiwaki , K. Kotake	AIP Conference Proceedings, Volume 1594, ORIGIN OF MATTER AND EVOLUTION OF GALAXIES 2013		AIP Publishing LLC		01/01/2014	290-295	No	No	Conference	http://scitation.aip.org/content/aip/proceeding/aipcp/10.1063/1.4874084
Asymmetric neutrino production in magnetized proto-neutron stars in fully relativistic mean-field approach 10.1063/1.4874 075	Tomoyuki Maruyama , Toshitaka Kajino , Nobutoshi Yasutake , Jun Hidaka , Takami Kuroda , Tomoya Takiwaki , Myung-Ki Cheoun , Chung-Yeol Ryu , Grant J. Mathews	AIP Conference Proceedings, Volume 1594, ORIGIN OF MATTER AND EVOLUTION OF GALAXIES 2013		AIP Publishing LLC		01/01/2014	234-238	No	No	Conference	http://scitation.aip.org/content/aip/proceeding/aipcp/10.1063/1.4874075
Measurement of alpha-induced reaction cross sections on erbium isotopes for # process studies 10.1063/1.4874 067	G. G. Kiss , T. Sz#cs , Zs. T#r#k , Zs. F#l#p , Gy. Gy#rky , Z. Hal#sz , E. Somorjai , T. Rauscher	AIP Conference Proceedings, Volume 1594, ORIGIN OF MATTER AND EVOLUTION OF GALAXIES 2013		AIP Publishing LLC		01/01/2014	196-200	No	No	Conference	http://scitation.aip.org/content/aip/proceeding/aipcp/10.1063/1.4874067
Deconfinement to quark matter in neutron stars - The influence of strong magnetic fields 10.1063/1.4795 968	V. Dexheimer , R. Negreiros , S. Schramm , M. Hempel	XII Hadron Physics. AIP Conference Proceedings, Volume 1520.		AIP		01/01/2013	264-269	No	No	Conference	http://scitation.aip.org/content/aip/proceeding/aipcp/10.1063/1.4795968
The role of fission on neutron star mergers and its impact on the r-process peaks 10.1063/1.495 3296	M. Eichler , A. Arcones , A. Kelic , O. Korobkin , K. Langanke , T.	Table of Contents CETUP* 2015 – WORKSHOP ON DARK MATTER, NEUTRINO PHYSICS AND ASTROPHYSICS AND PPC		Author(s)	American Institute of Physics, USA	01/01/2016	040004	Yes	Yes	Conference	http://aip.scitation.org/doi/abs/10.1063/1.4953296

		Marketin , G. Martinez-Pinedo , I. Panov , T. Rauscher , S. Rosswog , C. Winteler , N. T. Zinner , F.-K. Thielemann	2015									
The LOFT mission concept: a status update 10.1117/12.2233 161	M. Feroci ... , F. K. Thielemann .. et al.	Space Telescopes and Instrumentation 2016: Ultraviolet to Gamma Ray			SPIE	USA	25/07/2016	99051R	Yes	Yes	Conference	http://proceedings.spiedigitallibrary.org/proceeding.aspx?doi=10.1117/12.2233161
Theory considerations for nucleosynthesis beyond Fe with special emphasis on p-nuclei in massive stars 10.1063/1.49533 00	T. Rauscher , N. Nishimura , R. Hirschi	CETUP* 2015 – WORKSHOP ON DARK MATTER, NEUTRINO PHYSICS AND ASTROPHYSICS AND PPC 2015			Author(s)	American Institute of Physics, USA	01/01/2016	040008	Yes	Yes	Conference	http://aip.scitation.org/doi/abs/10.1063/1.4953300
Inhomogeneous chemical evolution of r-process elements 10.1063/1.49533 01	B. Wehmeyer , M. Pignatari , F.-K. Thielemann	CETUP* 2015 – WORKSHOP ON DARK MATTER, NEUTRINO PHYSICS AND ASTROPHYSICS AND PPC 2015			Author(s)	American Institute of Physics, USA	01/01/2016	040009	Yes	Yes	Conference	http://aip.scitation.org/doi/abs/10.1063/1.4953301
Production Uncertainties of p-Nuclei in the #-Process in Massive Stars Using a Monte Carlo Approach 10.7566/JPSCP .14.010509	T. Rauscher , N. Nishimura , R. Hirschi , G. Cescutti , A. St. J. Murphy , A. Heger	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)			Journal of the Physical Society of Japan		28/02/2017	010509	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JPSCP .14.010509
Nucleosynthesis in Supernovae, Hypernovae/Gamma-ray Bursts and Compact Binary Mergers 10.7566/JPSCP .14.010605	Friedrich-Karl Thielemann	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)			Journal of the Physical Society of Japan		28/02/2017	010605	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JPSCP .14.010605
Quasi-Periodic Gravitational-Wave Emission due to the SASI Motion 10.7566/JPSCP .14.010611	Takami Kuroda , Kei Kotake , Tomoya Takiwaki	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)			Journal of the Physical Society of Japan		28/02/2017	010611	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JPSCP .14.010611

How Well Do We Know The Supernova Equation of State? 10.7566/JSPSCP .14.010802	Matthias Hempel , Micaela Oertel , Stefan Typel , Thomas Klähn	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)		Journal of the Physical Society of Japan		28/02/2017	010802	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JSPSCP .14 .010802
Inhomogeneous Chemical Evolution of r-process Elements in the Galactic Halo 10.7566/JSPSCP .14.020201	Benjamin Wehmeyer , Marco Pignatari , Friedrich-Karl Thielemann	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)		Journal of the Physical Society of Japan		28/02/2017	020201	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JSPSCP .14 .020201
Simulation of X-ray Bursts and Superbursts 10.7566/JSPSCP .14.020509	Julia Reichert , Sofie Fehlmann , Rubén Cabezón , Friedrich-Karl Thielemann	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)		Journal of the Physical Society of Japan		28/02/2017	020509	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JSPSCP .14 .020509
Nucleosynthesis in 2D Core-Collapse Supernova Long-Term Simulations of 11.2 and 17.0 M_{\odot} Progenitors 10.7566/JSPSCP .14.020604	Marius Eichler , Ko Nakamura , Tomoya Takiwaki , Takami Kuroda , Kei Kotake , Matthias Hempel , Ruben Cabezón , Matthias Liebendörfer , Friedrich-Karl Thielemann	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)		Journal of the Physical Society of Japan		28/02/2017	020604	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JSPSCP .14 .020604
PUSHing Core-Collapse Supernovae to Explosions in Spherical Symmetry: Nucleosynthesis Yields 10.7566/JSPSCP .14.020608	Sanjana Sinha , Carla Fröhlich , Kevin Ebinger , Albino Perego , Matthias Hempel , Marius	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)		Journal of the Physical Society of Japan		28/02/2017	020608	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JSPSCP .14 .020608

		Eichler , Matthias Liebendörfer , Friedrich-Karl Thielemann										
Explosion Dynamics of Parametrized Spherically Symmetric Core-Collapse Supernova Simulations 10.7566/JPSCP .14.020611	Kevin Ebinger , Sanjana Sinha , Carla Fröhlich , Albino Perego , Matthias Hempel , Marius Eichler , Jordi Casanova , Matthias Liebendörfer , Friedrich-Karl Thielemann	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)		Journal of the Physical Society of Japan		28/02/2017	020611	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JPSCP .14.020611	
Multi-dimensional Core-Collapse Supernova Simulations with Neutrino Transport 10.7566/JPSCP .14.020703	Kuo-Chuan Pan , Matthias Liebendörfer , Matthias Hempel , Friedrich-Karl Thielemann	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)		Journal of the Physical Society of Japan		28/02/2017	020703	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JPSCP .14.020703	
Neutrino-Nucleon Interactions in Supernova: Hartree Response & Approximations 10.7566/JPSCP .14.020707	Andreas Lohs , Gabriel Martinez-Pinedo , Tobias Fischer	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)		Journal of the Physical Society of Japan		28/02/2017	020707	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JPSCP .14.020707	
A Systematic Analysis of Hybrid Stars Using a Hadronic Equation of State Suitable for Core-Collapse Supernovae 10.7566/JPSCP .14.020804	Oliver Heinemann , Matthias Hempel , Friedrich-Karl Thielemann	Proceedings of the 14th International Symposium on Nuclei in the Cosmos (NIC2016)		Journal of the Physical Society of Japan		28/02/2017	020804	No	Yes	Conference	http://journals.jps.jp/doi/10.7566/JPSCP .14.020804	

A2. Research expeditions

List of expeditions

Period (start-end)	Place	Purpose
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A3. Awards and recognitions

List of awards and recognitions

Award type	Title of the award	Person to whom the award was made	Year	Short description of the reason the award was made (if applicable)	Any further information / clarification
Fellowship / membership of learned society	Fellow of the American Physical Society	Friedrich K. Thielemann	1996		APS Award
Research Prize / Research Medal	Hans A. Bethe Prize	Friedrich K. Thielemann	2008	For his many outstanding theoretical contributions to the understanding of nucleosynthesis, stellar evolution and stellar explosions through applications to individual objects and to cosmic chemical evolution	APS Prize
Research Prize / Research Medal	Humboldt Research Award	Friedrich K. Thielemann	2009		Humboldt Foundation
Research Prize / Research Medal	Lise Meitner Prize	Friedrich K. Thielemann	2012	for seminal contributions to the description of nuclear processes in astrophysical environments that have changed our modern understanding of stellar evolution, supernovae explosions and nucleosynthesis	EPS prize
Membership of editorial boards	Associate Editor, Nuclear Physics A	Friedrich K. Thielemann	1998		
Membership of editorial boards	Associate Editor for Astrophysics, Reviews of Modern Physics	Friedrich K. Thielemann	2006		
Fellowship / membership of learned society	Member of the Academia Europaea (The Academy of Europe)	Friedrich K. Thielemann	2015		Academy of Europe

A4. Patents, licensing, intellectual property

List of patents, licensing, intellectual property

Type of IP Rights	Confidential	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant(s) (as on the application)
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A5. Dissemination to non-academic audience

List of disseminations								
No.	Type of activities	Main Leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
1	Media briefings	UNIVERSITAET BASEL	Past and Present Challenges in Nuclear Astrophysics	01/03/2013	SPG Mitteilungen, Vol 39, Progress in Physics (31)	Scientific community (higher education, Research) - Industry		Switzerland
2	Media briefings	UNIVERSITAET BASEL	Making the Elements in the Universe,	18/06/2013	Europhysics News 44, 23	Scientific community (higher education, Research)		Europe
3	Presentations	UNIVERSITAET BASEL	Formation of the Elements in the Universe	07/03/2013	50 Years of TRIGA Research at ATI Vienna, Vienna	Scientific community (higher education, Research) - Industry - Civil society - Policy makers - Medias	400	Austria
4	Presentations	UNIVERSITAET BASEL	Wo alles herkommt: Die Entstehung der Elemente im Universum	15/11/2013	Marienstatter Zukunftsgespraechе, Hachenburg, Germany	Civil society - Medias	200	Germany
5	Presentations	UNIVERSITAET BASEL	Der Stoff der von den Sternen kam	23/01/2014	Planetarium Mannheim	Civil society - Medias	200	Germany
6	Media briefings	UNIVERSITAET BASEL	Die Entstehung der Atome - Eine Synthese von Mikro- und Makrokosmos	01/02/2014	http://link.springer.com/chapter/10.1007%2F978-3-658-04158-8_10	Scientific community (higher education, Research) - Industry - Civil society - Policy makers - Medias		Germany, Austria, Switzerland
7	Presentations	UNIVERSITAET BASEL	Interface of Nuclear Physics and Astrophysics	10/02/2014	Institut Pluridisciplinaire Hubert Curien, Strassburg	Scientific community (higher education, Research)	100	France, UK; Belgium
8	Presentations	UNIVERSITAET BASEL	Warum gibt es Gold und Silber im Universum?	13/05/2014	Kinderuniversität Basel	Civil society - Medias	300	Switzerland

9	Presentations	UNIVERSITAET BASEL	Stellar Evolution / Explosions, Nuclear/Particle Physics Input, Origin of the Elements and Evolution of Galaxies	30/09/2014	University of Basel	Scientific community (higher education, Research)	40	France, Germany, Israel, Italy, Japan, Russia, Switzerland, Taiwan, Ukraine, UK, USA
10	Other forms of dissemination	UNIVERSITAET BASEL	Brainstorming and Fun: Stellar Evolution / Explosions, Nuclear/Particle Physics Input, Origin of the Elements and Evolution of Galaxies	30/09/2014	http://phys-merger.physik.unibas.ch/~group/brainstorm2014.html	Scientific community (higher education, Research)		entire world
11	Other forms of dissemination	UNIVERSITAET BASEL	Researching how stars explode	31/10/2014	http://www.hpc-ch.org/researching-how-stars-explode/	Scientific community (higher education, Research) - Industry - Civil society - Policy makers - Medias		Switzerland
12	Media briefings	UNIVERSITAET BASEL	Discovery of Gravitational Waves and Research in Basel	12/02/2016	https://telebasel.ch/2016/02/12/auch-die-uni-basel-profitiert/	Civil society - Medias		Switzerland
13	Presentations	UNIVERSITAET BASEL	Brainstorming and Fun: Compact objects, their equation of state, related explosive events, and their nucleosynthesis	29/09/2016	Dept. of Physics, University of Basel	Scientific community (higher education, Research)	70	Switzerland, Germany, France, Italy, UK, Poland, Sweden, Russia, Israel, USA, Japan
14	Presentations	UNIVERSITAET BASEL	Highschool Lecture: Gravitationswellen vom Verschmelzen kompakter Objekte	23/12/2016	Large Lecture Hall, Physics Department	Civil society	200	Switzerland
15	Presentations	UNIVERSITAET BASEL	Saturday Morning Physics: Schwarze Löcher, Gravitationswellen und die schwersten Elemente im Universum	25/02/2017	Large Lecture Hall, Physics Department	Civil society - Medias	200	Switzerland

A6. Other significant outputs / information

Information on other important outputs which have arisen - wholly or partly - from this project.

(Only for ERC projects selected from the 2012 and 2013 calls for proposals)

This grant agreement includes special clause 39, requiring you to make best efforts towards open access to publications resulting from this project. Should, despite your best efforts, not all publications be available in open access, please give reasons why this is the case.

Attachments	SupernovaHandbookfkt.pdf, code_comparison.pdf, annrevfktfinalff.pdf
Project No.:	321263
Project acronym:	FISH
Project title:	FaInt Supernovae and Hypernovae: Mechanism and Nucleosynthesis
Project starting date:	01/01/2013
Project duration:	48
Principal Investigator name:	Prof. Friedrich-Karl Wilhelm Thielemann
Report submitted by:	UNIVERSITAET BASEL
Date:	02/04/2017