# europhysicsnews

THE MAGAZINE OF THE EUROPEAN PHYSICAL SOCIETY

News and views from the former EPS presidents

The nuclear history of the universe

On the physics of high-rise building collapses

We shoot a bullet vertically. Where will it land?

EPS directory

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edp sciences


# europhysicsnews

**Cover picture:** NASA's Hubble Space Telescope has unveiled in stunning detail a small section of the expanding remains of a massive star that exploded about 8,000 years ago. Called the Veil Nebula, the debris is one of the best-known supernova remnants, deriving its name from its delicate, draped filamentary structures. The entire nebula is 110 light-years across, covering six full moons on the sky as seen from Earth, and resides about 2,100 light-years away in the constellation Cygnus, the Swan. © NASA/ESA/Hubble Heritage Team

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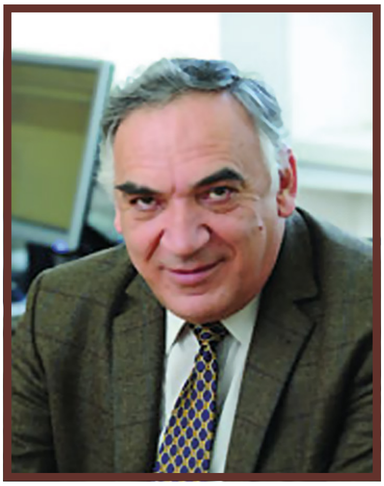


[EDITORIAL]

# Large-Scale Research Infrastructures: essential framework of today's physics research

**Large-scale research infrastructures (LSRI) are today an essential part of the physics research landscape. The activities at such facilities are and will be centered on the frontline research in the hottest physics topics, most likely to generate breakthroughs in knowledge.**

The exotic and ambitious today's research projects inherently involve big concentration of human and financial resources and LSRI foster large multinational collaborations between groups from many institutes and universities.

LSRI are complementary to small-scale research infrastructure (SSRI), which in turn are essential in enhancing the contribution of the physics community to the big European Projects. SSRI are ideal places for educating and training young scientists, as well as for developing instruments and measurement methods intended for specific LSRI. Europe showcases several success stories in this area.

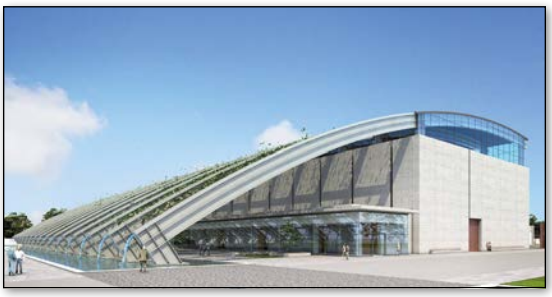
In a long tradition, the Romanian physics community, with balanced research programs at the two types of facilities, offered the country a permanent international openness with remarkable achievements. The "Horia Hulubei" National Institute of Physics and Nuclear Engineering (IFIN-HH), Bucharest-Magurele, stands at the forefront of the Romanian science, both in terms of research infrastructures and personnel. It addresses a large spectrum of R&D activities in fundamental and applied research. While focusing its mission on advanced investigations in atomic and sub-atomic physics, the IFIN-HH is also committed to increase the positive impact of the nuclear research on industry and the society at large. The institute has shown to be a valid interlocutor and partner in the Euro-Atlantic science and technology endeavour, substantively collaborating with Large-Scale Facilities such as GSI/FAIR-Darmstadt, GANIL/SPIRAL2-Caen, CERN-Geneva, JINR-Dubna.

The 2012 decision of the European Commission for Romania to host the nuclear pillar of the Extreme Light Infrastructure project (ELI-NP) – the E.U.'s first investment in research infrastructure for the new member states – (along pillars in Czech Republic and Hungary), was all possible because of the worldwide recognized research capacity of the Institute. With ELI-NP there is a unique opportunity to rise in the world hierarchy, since it will be the most advanced research facility focusing on the study of photonuclear physics and its applications.

Apart from creating excellent scientific research conditions, ELI-NP will contribute to major changes in the Romanian society, reversing the 'brain drain' and attracting new high-tech companies to the region. LSRI are indeed well-known to act as catalysts for connecting the research community with both academia and industry. In this respect ELI-NP will also facilitate a variety of important applied research projects of high socio-economic value. In order to create a breeding ground for start-up companies around a major infrastructure, an open association for research and business was created. Moreover, governmental, regional and local authorities together with academia and business entities will develop a Science Park to offer specialized services and logistics in various fields of engineering, medicine, telecommunications and others.

**Another proof of how excellence in science contributes to European cohesion and development.**

▾ Artist impression of the ELI-NP project.



It is evident that co-financing this kind of projects both by the European Commission and by national Governments represents the best opportunity for Central and Eastern Europe to generate qualified job opportunities and to become an advanced pole for innovation.

The new pan-European research institute ELI-ERIC, based on the three pillars, will contribute to the strengthening and promotion of European scientific research worldwide. It will also foster technology transfer and commercialization of public funded research, to the benefit of society at large. This is another proof of how excellence in science can contribute to European cohesion and development. ■

■ **Nicolae-Victor Zamfir**
*Member of the EPS Executive Committee*

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# Statement by Christophe Rossel, President of the EPS, after UK's decision to leave the EU

**Mulhouse, 24 June 2016 – The European Physical Society (EPS) regrets the outcome of the vote by the British people and their decision to leave the European Union.**

In spite of all possible consequences that might arise from this choice, the popular decision must be respected like in all democratic processes. The result of the UK's referendum will certainly bring the leaders to start a wider discussion on the future of the union. Even if Europe might lose a strong and respected research partner, the scientific community must remain united and aim at further fostering the international collaboration, especially when urgent solutions to global challenges are required. Indeed, one of the strengths of scientific research is its international nature and the free exchange of people and ideas across borders, a policy and philosophy strongly supported by EPS. At a time when the EU Commission wants to develop and implement open science policy to improve the quality and impact of European science, in particular by better interconnecting research infrastructures, it would be unfortunate to see such efforts refrained by political decisions.

The withdrawal of the UK from the EU will indeed have negative consequences for its universities and researchers. Like Switzerland is experiencing it with its status of partial associated country in Horizon 2020 and all the required negotiations to reach bilateral agreements, access to EU funding will become more difficult for UK scientists. In spite of yesterday's vote, EPS will further develop and strengthen its excellent relationship with the Institute of Physics (IOP), and this with the help of all its other national member societies. It is the mission of EPS to advocate for physics research and its contribution to the economic, technological, social and cultural advancement in Europe. Its role is also to represent the European physics community in providing independent input into science policy issues. In this function EPS calls on the UK Government and the EU governing bodies to act with all respectful means to ensure a smooth transition and maintain the good integration of the UK scientists within the European landscape. ■

■ **Christophe Rossel,** *EPS President*

# News and views
# from the former EPS presidents

**At EPS Council 2016 in Mulhouse eight of the thirteen invited former EPS presidents came and it was a great pleasure and honor to welcome them.**

Present were Renato A. Ricci, Italy (1988-91), Norbert Kroo, Hungary (1993-95), Herwig Schopper, CERN, Germany (1995-97), Dennis Weaire, Ireland (1997-99), Martial Ducloy, France (2001-03), Ove Poulsen, Denmark (2005-07), Fritz Wagner, Germany (2007-09) and John Dudley, France (2013-15). Unable to attend were Antonino Zichichi, Italy (1978-80), Arnold Wolfendale, UK (1999-01), Martin C. E. Huber, Switzerland (2003-05), Maciej Kolwas, Poland (2009-11) and Luisa Cifarelli, Italy (2011-13).

▲ **(Left to right) TOP:** Ove Poulsen, Christophe Rossel, Martial Ducloy, Dennis Weaire **BOTTOM:** Norbert Kroo, John Dudley, Renato A. Ricci, Herwig Schopper, Fritz Wagner

Taking advantage of the presence of these former EPS presidents, a roundtable was organized to discuss the past and future of EPS from their own perspectives. To help the discussion several questions were addressed and the statements from the contributing former president are summarized here.

### How has EPS changed or stayed the same since your time as President?

According to N. Kroo, EPS has played a significant role in European research and education and not only in physics. In the eighties, nineties and even after 2000 the drive has been to decrease the gap between East and West. Divisional and general conferences, the student mobility programme and many other activities resulted in European added value not only for physics research but in a more general field too. "To build the future it is useful not to forget the past" says R.A. Ricci. In answering the question if and how the EPS did change, he thinks that one has to refer primarily to the different general context thirty years ago when the East-West European relationships were difficult. EPS played a very important role in fostering cooperation between the member physical societies and scientific institutions all over Europe. An important achievement, during Ricci's presidency in 1989, was the merging, strongly supported by EPS, of the eastern and western German Physical Societies one year before the fall of the Berlin Wall. It was also the period of the launch of the "Europhysics Letters" founded in 1986 by merging the French "Journal de Physique Lettres" and the Italian "Lettere al Nuovo Cimento". In 1988, EPS celebrated its 20th anniversary, with the participation, even then, of past Presidents (G. Bernardini, H.B.G. Casimir, A. Zichichi, A.R. McIntosh, G.H.Stafford, and W. Buckel) already discussing the "Past and Future of the EPS". At that time the financial problems were important enough to decide on sharing the EPS secretariat between Geneva and Budapest, thanks to the effort of the past Secretary General Gero Thomas.

When H. Schopper was President in 1995-97, EPS was in great difficulties because the secretariat in Geneva turned out to be much too expensive. A new home could be found with the help of the French Physical Society and the supportive local authorities at Mulhouse. At that time EPS could maintain its second secretariat in Budapest thanks to the Hungarian Academy of Sciences, which was essential to provide a bridge to the national societies behind the iron curtain. This was one of the great achievements of EPS and showed how science can help to bring nations together. Although the iron curtain has disappeared the task to keep European physics together and make it more visible is still very important. The name of EPS implies that now one of its main addressees is the European Union and the efforts of the President and the Executive Board to strengthen its influence at Brussels deserve all support. It was under M. Ducloy's presidency that the plans for a new building on the campus of the University of Haute Alsace were made and EPS moved into its new location in 2004. The official inauguration took place in January 2005, just in time to celebrate also the launch of the World Year of Physics, an initiative started in 2000 by the EPS and its then President-elect, M. Ducloy. In his opening address, M. Huber, EPS president at that time, mentioned that "the EPS building will serve the physics community, be a warrant of international exchange among scientists, and be an active interface with the local University and the region of Alsace".

Since he left presidency 8 years ago, F. Wagner notices that EPS became more professional and uses better tools to become more effective. There are also new activities and each of the presidents left something that makes the society more useful and increases its visibility. A nice example is the EPS Historic Sites programme started under Luisa Cifarelli. Another good sign is that the secretariat proposes actions to increase its own efficiency, demonstrating the right team spirit. This year´s Council also radiated a very good atmosphere between the EPS and its member societies.

**Where do you see lessons-learned?**

The past achievements serve on one hand as a good basis for present and future activities but on the other they are the driving arguments for future actions. According to H. Schopper since those old and precarious times EPS has found its significant place as an association of national physical societies and established its firm role in the European scientific landscape. However, some problems are long-lived, for instance the fact that the size and strength of various national societies is extremely different. Some of them should open up much more to younger members and to physicists from industry and in education.

During Wagner's time the opportunity of an office in Brussels was examined but finally dropped for two basic reasons: (1) it was doubtful whether EPS could induce an identifiable benefit in the biosphere of the Commission facing the lobbying activities of scientific societies with billion Euro budgets behind them. (2) 2008 was a recession year and the level of support by the major member societies was under discussion. It was not the time to start a big investment on a questionable financial basis. 'An effective office in Brussels is equivalent to having an elephant in bed. You will notice when he turns around'.

Nevertheless the EPS strategy plan 2010+ initiated under Maciej Kolwas's presidency has shown the importance of a presence in Brussels and the review of this strategy presented at today's Council confirms that EPS is on the right path.

**Where could EPS improve further?**

EPS's experience in integrated research on European level could serve as a useful source for other fields in society, badly needed in our crisis-after-crisis time. In these activities success depends on how we can find partners outside physics, advises N. Kroo. We have to build stronger partnership with EU institutions in Brussels, needing stronger presence there with an experienced staff. EPS should try to do contract-based work for the Commission, contributing not only to our finances but implanting our experience and skills into European research. The efficient use of European large facilities may also benefit from our experience and know-how. European industry should benefit more from our research experience. This has been a traditional weakness and EPS may contribute to the badly needed changes in this field.

'The ground rules for EPS have not changed' says F. Wagner. EPS offers services to its members which are – and this is the difficulty – rather different in their needs and expectations. For all member categories the science oriented activities – conferences, publications, EPN, eEPS and presence on internet – are of high importance. The scientific activities of the Divisions and Groups should get all support and should be closely monitored. In important cases of fast emerging research topics, as noted by M. Ducloy, opportunities should be taken to launch new Divisions. EPS conferences could be organized in a firmer format to be better recognizable as an EPS activity. The President, the vice-President or the Executive Committee could play a more active role *e.g.* in the opening ceremony. EPS-supported conferences should be regularly scrutinized to what extent they could become part of the standard conference portfolio of EPS. A mechanism should be present to recognize upcoming new research topics in physics or in neighboring interdisciplinary areas. Such cases should be identified and analysed by the involved Divisions and Groups for their conference potential. This view on conferences is shared by D. Weaire who recommends that this activity gets some fresh impetus. Perhaps a status report would be a good start. What is the size spectrum of (all) physics-related conferences, what are the charges or income they produce, who attends them (students, staff, senior staff, and physicists from industry and education)? At the same time the possibilities for new kinds of conference might be explored. In the Internet age, surely they will not stay the same, even if people go to them for a temporary release from punching their keyboard!

▾ The EPS past-presidents at the national French museum *cité de l'automobile* (www.citedelautomobile.com)

**What are the new challenges in science, education, outreach, etc.?**

There are several challenges and threats as outlined here.

It is worrisome that physics as a school discipline seems to be phased out in many regions and replaced by a topic called natural sciences. Of course education is a national issue because of the language. But EPS could help to point out the societal threats, *e.g.*, by preparing a comparative study of physics school education in Japan, Korea, and China where - in F. Wagner's expectation - the value of physics is better understood by society. Another serious threat is that the public does not accept the freedom and independence of science any longer. There is the notion of societally accepted research. Loser of this development will be basic research. This tendency has to be counteracted by all means. A related threat is political correctness. We should be concerned that science could lose its major quality, namely skepticism. This trend seems to be more pronounced among natural scientists and engineers than among humanists.

Other critical issues raised by several former presidents are related to trends in bibliometric and scientific assessments. Indeed the evaluation in science gets more complicated and decision makers tend to avoid personal responsibility by using instead all kinds of indices or factors. However, when applied without deeper understanding of their meaning, these indices can lead to completely wrong and unjust decisions for employment, promotions or prizes. A special problem arises in domains with large collaborations, like particle and nuclear physics, astrophysics and others. Publications are signed usually by hundreds or even thousands of authors and an evaluator outside the field is completely lost. Peer review should have a significant weight in the evaluation of the performance first of all of individuals and groups. A solution to these problems is not obvious, but EPS could use its influence to find improvements, both by changing the practices of publications and evaluation.

Another concern raised by H. Schopper is the evaluation of large scientific infrastructures such as LHC at CERN that are getting more costly, and hence funding agencies ask for their net social value. The new tendency is to apply economics cost/benefit analysis, developed for industrial projects, also to basic science infrastructures, ignoring other benefits in basic knowledge, technology transfer and education.

The evaluation of research performance on formal basis is thus far from satisfactory. EPS could and should find those gaps of a healthy process where we could contribute and N. Kroo suggested that the downscaled activity of ESF could be the opportunity to fill up such gaps.

One of the tools that EPS possesses to address challenges in science, research, education and outreach is its Forum Physics and Society initiated by former president O. Poulsen. Based on the output of such workshops, EPS can produce relevant and timely statements and position papers.

### EPS in a global world and alongside Social Media?

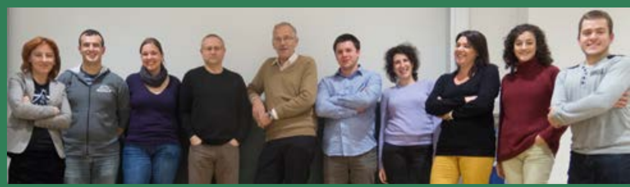
F. Wagner always felt that EPS is honoured outside Europe even more than inside. Therefore, EPS can benefit from globalisation. Nowadays, the large European research organisations see the need to open institutions outside their original territory. Often, they do not export research areas rather than research structures. In a similar way, EPS could combine topical conferences with other countries changing venue from case to case.

In this global world, EPS has a role to play in providing scientific evidence to EU initiatives and recommendations on grand challenges such as energy strategies, environmental issues, *etc.* It should also continue fostering research cooperation among the various European countries in spite of different political and social contexts, and different size and structure of their Physical Societies. Finally the position and the visibility of EPS worldwide is of extreme importance, today more than in the past, and the improvement of the relationships with APS and other overseas representative Institutions will be of great value for the future perspectives of the scientific community as a whole. The International Year of Light IYL2015, cosponsored by EPS and chaired by our past president John Dudley is the perfect example of what our Society can achieve to impact our world. ■

■ **Summarized by C. Rossel,** *EPS President, 3 May 2016*

# TURNING POINT FOR YOUNG MINDS

**It was in 2010 when EPS launched the Young Minds (YM) project, aimed to encourage and support professional skills of the next generations of physicists in Europe. Six years have passed, and like every year we look back to see what we did and what we should do.**



▲ The YM action committee meeting in Konstanz, autumn 2015

YM provides the creation of local student groups, called YM Sections, engaged in the organization of seminars and workshops, in outreach activities, or even in the implementation of networking collaborations. Nowadays, the project includes 400 young scientists from over 35 Sections in 20 countries. The growth trend of the project was shown during the EPS Council in 2016 in Mulhouse: the number of national physical societies supporting YM is increasing in proportion to the number of sections. But the YM growth is not only in the numbers, but also in the quality of the activities carried out by its members. This became evident during the annual meeting of all the YM Sections, held at the Eötvös Loránd University on 15th-16th July 2016 in Budapest. Most of the sections and their activities are in the field of outreach, followed by professional development and eventually networking.

The growth in the number of sections has made it indispensable to enlarge the YM action committee (AC), which is responsible for the project management. The YM AC is composed of senior scientists, young scientists, and people from the EPS staff, with a total of 10 members.

The senior part is always composed of the EPS President and a delegate from the ExCOM. The EPS staff members ensure the best connection between the project and EPS: the Secretary General of the EPS, David Lee; and the Conference Manager assistant, Ophélia Fornari. The young part was enlarged in 2015 up to six members to whom EPS gave the opportunity not only to develop as physicists but also to develop their social and management skills. For the last 3 years, this AC has been led by Antigone Marino from Naples (Italy). Now, after the last YM AC meeting, where the members elected a new chair, Eva Salvador from Castellón (Spain) will have to manage the new challenges for YM and EPS, and it will be a new turning point for the YM project history. ■

Eva Salvador Balaguer (YM chair)
Antigone Marino (YM past chair)

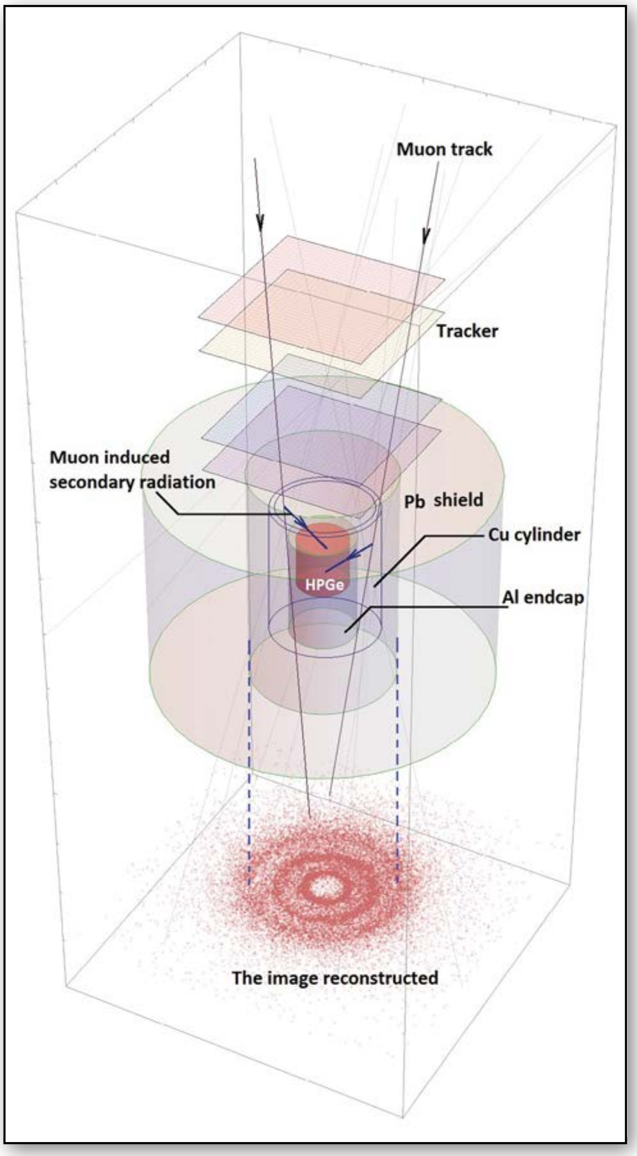
# Highlights from European journals

NUCLEAR PHYSICS

## Expanding Frontiers of Cosmic-ray Muon Imaging

There are lots of imaging devices which use large doses of ionizing radiation or strong magnetic fields for image production. The idea to use natural omnipresent radiation like the cosmic muons for imaging is not new. The imaging by cosmic-origin muons has now a several decades old tradition. The cosmic-ray muons can be used for imaging of large structures, or high-density objects with high atomic number. The first task can be performed by measurement of muon absorption within very thick material layer, while the second approach is based on muon multiple scattering.

▾ The principles of novel cosmic-ray muon imaging technique.



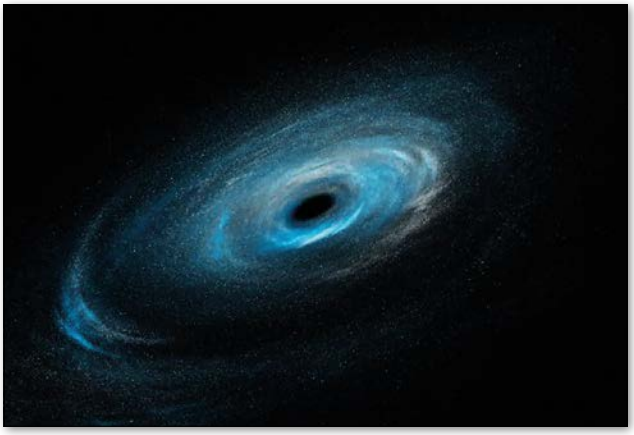

However, the additional use of muon created secondaries (not used at all in previous muon imaging methods) might significantly widen the perspectives of this harmless, non-destructive analytical technique. In the presented novel approach, the images are produced by tracking the incident muons and detecting in coincidence the radiation from the muon induced secondaries (mostly bremsstrahlung from the electrons). For the first time, small-dimension objects with low atomic number can be visualized precisely. Thus the list of elements, as well as range of dimensions of objects which can be imaged is significantly expanded. ■

■ **I. Bikit**, **D. Mrdja**, **K. Bikit**, **J. Slivka**, **N. Jovancevic**, **L.Oláh**, **G. Hamar** and **D. Varga**,
'Novel approach to imaging by cosmic-ray muons',
*EPL* **113**, 58001 (2016)

RELATIVITY

## You were right: rotational motion is relative, too, Mr Einstein!

**Extension of the relativity theory to rotational motion, one hundred years after Einstein first published the general theory of relativity.**



▴ Einstein's relativity theory also applies to rotational motion.
© sakkmesterke / Fotolia

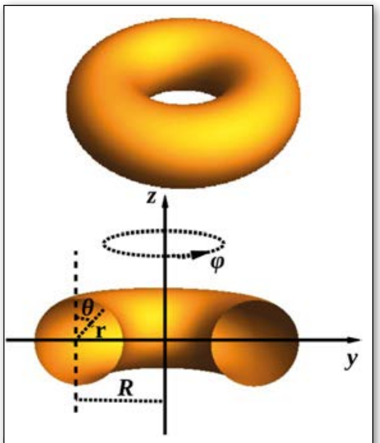
It has been one hundred years since the publication of Einstein's general theory of relativity in May 1916. In a paper recently published, the authors demonstrate that the rotational motion in the universe is also subject to the theory of relativity. Until now, no-one has considered a possible connection between the general principle of relativity and the amount of dark energy in the universe, which is associated with the acceleration of the expansion of the universe, discovered in 1998. This connection can be established, they argue, by using the phenomenon of inertial dragging. When formalised in mathematical terms, the condition for inertial dragging yields an equation for calculating the amount of dark energy. The solution of that equation is that 73.7 % of the present content of the universe is in the form of dark energy. This prediction, derived from the theory of general relativity, is remarkably close to the values arrived at by different types of observations. ■

■ **Ø. Grøn** and **T. Jemterud**,
'An interesting consequence of the general principle of relativity', *Eur. Phys. J. Plus* **131**, 91 (2016)

CONDENSED MATTER

# Surprising qualities of insulator ring surfaces

**Surface phenomena in ring-shaped topological insulators are just as controllable as those in spheres made of the same material**




▲ A ring torus embedded in 3D-space.

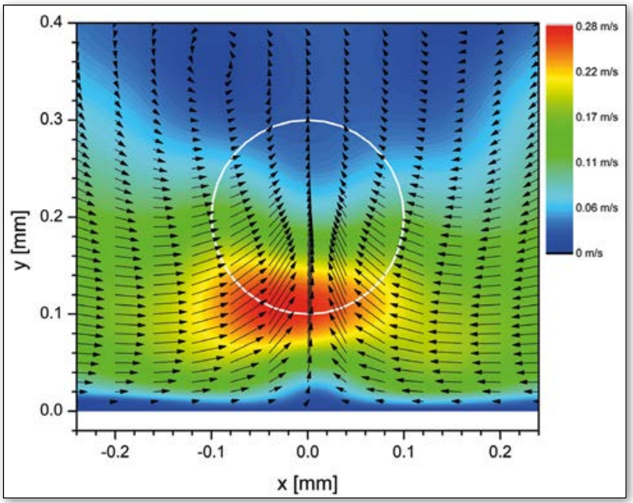
Topological insulators behave like insulators at their core and allow good conductivity on their surface. They owe their characteristics to a new quantum state within the material discovered in 2007 and 2009 for 2D and 3D materials, respectively. Scientists studying the surface of ring-shaped, or toric, topological insulators, have just discovered some characteristics that had only previously been confirmed in spheres. The authors describe their findings in a paper published recently. These results could hold considerable potential for applications in electronics. Indeed, this discovery means that the curved surface induces internal fields, called gauge fields, in the electrons carrying the electric charge located at the surface. By contrast, in graphene, similar fields have been induced by mechanical tensions or defects in the way the carbon atoms are arranged in the one-atom-thick honeycomb lattice. ■

■ **J. M. Fonseca**, **V. L. Carvalho-Santos**, **W. A. Moura-Melo** and **A. R. Pereira**,
'Berry phases and zero-modes in toroidal topological insulator', *Eur. Phys. J. B* **89**, 153 (2016)

PLASMA PHYSICS

# How repeated spot microdischarges damage microdevices

**New study blames temperature increase on locally reoccurring discharges in microelectronic devices.**




▲ Simulated velocity field of the microfilament in the vicinity of the dielectric wall after the train of 150 localised breakdowns.

In microelectronics, devices made up of two electrodes separated by an insulating barrier are subject to multiple of microdischarges—referred to as microfilaments—at the same spot. These stem from residual excited atoms and ions from within the material, the surface charge deposited on the insulating part of the device, and local temperature build-up. These reoccurrences can lead to the creation of pin-holes in the material of the microelectronic devices where they occur, and are due to local reductions in the electric field. Now, the authors have elucidated the mechanism of microdischarge reoccurrence, by attributing it to the temperature increase in a single microdischarge. These results were recently published. ■

■ **J. Ráhel**, **Z. Szalay**, **J. Čech** and **T. Morávek**,
'On spatial stabilization of dielectric barrier discharge microfilaments by residual heat build-up in air',
*Eur. Phys. J. D* **70**, 92 (2016)

QUANTUM PHYSICS

# The dynamics of compact laser pulses

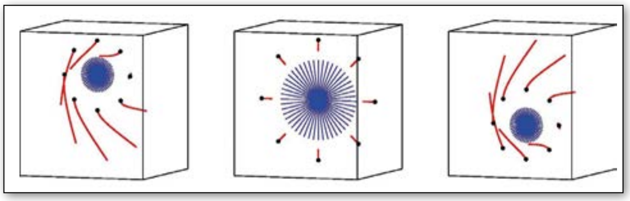
Current experimental activity exploring electromagnetic properties of single-cycle laser pulses with nanoscale objects requires efficient modelling tools that accommodate the spatial compactness of such pulses. Such tools will eventually require incorporation of quantum effects associated with these interactions in order to properly describe observations and yield practical applications.

By analogy with the model of a vibrating-rotating diatomic molecule, we have constructed an effective Hamiltonian for the general non-stationary quantum states of a laser pulse in vacuo.

Interactions with a classical fabricated meta-material with specified inhomogeneous and anisotropic characteristics are motivated by the magnetic moment interaction of qubit states of an electron with a classical (inhomogeneous) static magnetic field in the Stern–Gerlach experiment.

An important practical distinction arises since the laser states, unlike electrons, are electrically and magnetically neutral, offering new possibilities for controlling pairs of non-stationary entangled 3-level (qutrit) states using appropriately fabricated meta-materials.

▼ Qutrit states are motivated by trajectories (red) of point charged particles (black) interacting with a classical single-cycle laser pulse (blue).



Our effective Hamiltonian may have utility for the novel transfer of quantum information and for constructing new theoretical models of rapid single-cycle laser pulses interacting with quantum matter and classical fabricated nano-scale materials. ■

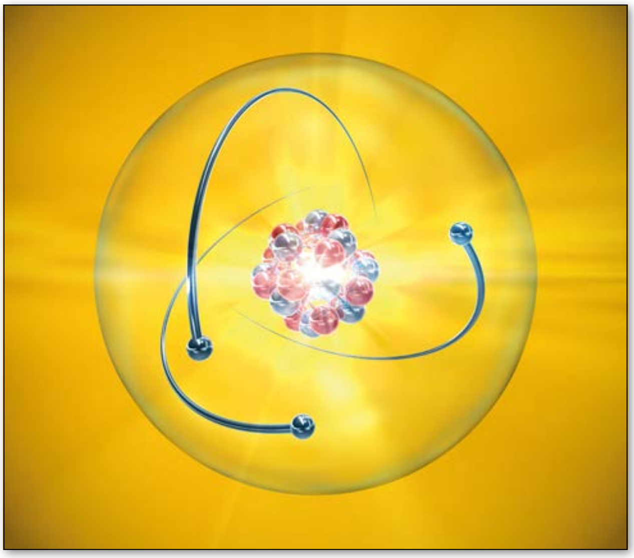
■ **S. Goto**, **R.W. Tucker** and **T.J. Walton**,
'The dynamics of compact laser pulses',
*J. Phys. A: Math. Theor.* **49**, 265203 (2016)

NUCLEAR PHYSICS

# Nuclear physics' **interdisciplinary progress**

**Theoretical nuclear physics could yield unique insights by extending methods and observations from other research fields.**

The theoretical view of the structure of the atom nucleus is not carved in stone. Particularly, nuclear physics research could benefit from approaches found in other fields of physics. Reflections on these aspects were just released in a new type of rapid publications which provides a forum for the concise expression of more personal opinions on important scientific matters in the field. In this work the authors use, among others, the example of superconductivity to explain how nuclear physics can extend physical concepts originally developed in solid state physics. Based on this example, they believe young nuclear physicists have the opportunity to bring their results to practitioners in



▲ Nuclear physics' interpretations could benefit from approaches found in other fields of physics. © Christoph Burgstedt / Fotolia

other fields of research. Conversely, they also need to rise to the challenge of using new insights and techniques from other disciplines to question the validity of their own theories and make nuclear physics research more powerful. ■

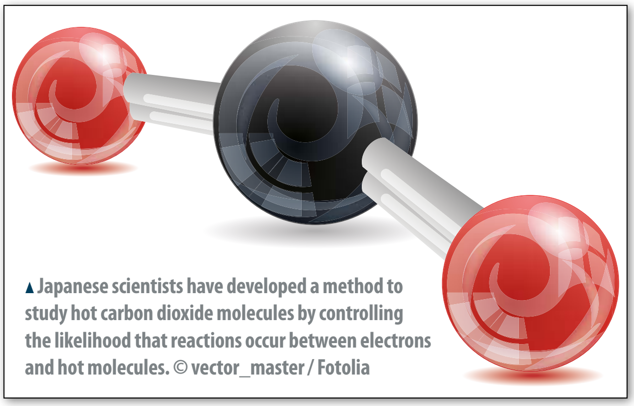
■ **P. F. Bortignon** and **R. A. Broglia**,
'Challenges in the description of the atomic nucleus: Unification and interdisciplinarity', *Eur. Phys. J. A* **52**, 64 (2016)

ATOMIC AND MOLECULAR PHYSICS

# Bending **hot molecules**

**New model for controlling hot molecules reactions, which are relevant to fusion, space exploration and planetary science.**

Hot molecules, which are found in extreme environments such as the edges of fusion reactors, are much more reactive than those used to understand reaction studies at ambient temperature. Detailed knowledge of their reactions is not only relevant to modelling nuclear fusion devices; it is also crucial in simulating the reaction that takes place on a spacecraft's heat

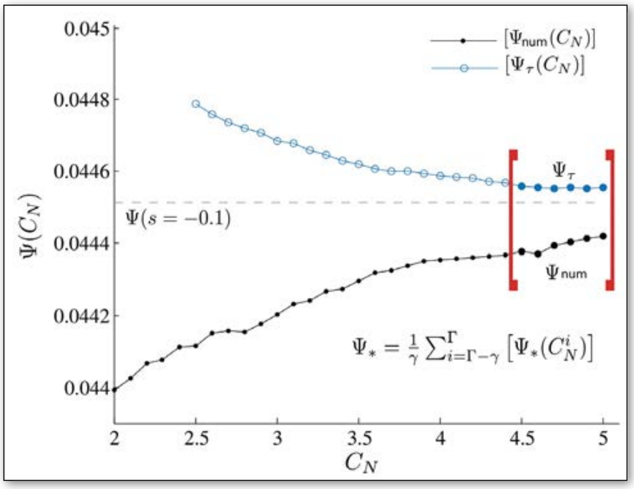


▲ Japanese scientists have developed a method to study hot carbon dioxide molecules by controlling the likelihood that reactions occur between electrons and hot molecules. © vector_master / Fotolia shield at the moment when it re-enters Earth's atmosphere. Further, it can help us understand the physics and chemistry of planetary atmospheres. In a novel and comprehensive work published recently, the authors reveal a method for controlling the likelihood that these reactions between electrons and hot molecules occur, by altering the degree of bending the linear molecules, modulated by reaching precisely defined temperatures. ■

■ **M. Hoshino**, **Y. Ishijima**, **H. Kato**, **D. Mogi**, **Y. Takahashi**, **K. Fukae**, **P. Limão-Vieira**, **H. Tanaka** and **I. Shimamura**, 'Change in resonance parameters of a linear molecule as it bends: Evidence in electron-impact vibrational transitions of hot COS and $CO_2$ molecules', *Eur. Phys. J. D* **70**, 100 (2016)

MATHEMATICAL PHYSICS

## Nurturing rare events: **discreteness effects in population dynamics**




▲ Improvement of the numerical estimation of a large deviation function after the time delay correction (blue), as a function of the cut $C_N$ in the final population size.

The occurrence of rare events can vastly contribute to the evolution of physical systems, because of their potential dramatic effects. Their understanding has gathered a strong interest and, focusing on stochastic dynamics, a variety of numerical methods have been developed to study their properties. Mathematicians have called 'large deviation function' (LDF) the main analytical tool. 'Cloning algorithms' allow their numerical evaluation and are based on population dynamics. The idea is to study rare trajectories by evolving several copies of the original dynamics, with a local-in-time selection process rendering the occurrence of rare trajectories typical in the evolved population. The simulation cost can be large and one is often restricted to small population sizes. We found a way to improve the determination of LDFs by: (a) getting rid of time intervals where discrete population effects are important, (b) performing over independent population runs an individual time delay, allowing globally reduction in numerical noise induced by the smallness of population. ■

■ **E. Guevara Hidalgo** and **V. Lecomte**, 'Discreteness effects in population dynamics', *J. Phys. A: Math. Theor.* **49**, 205002 (2016)

OPTICS

## Toward real-time 3D single-pixel imaging

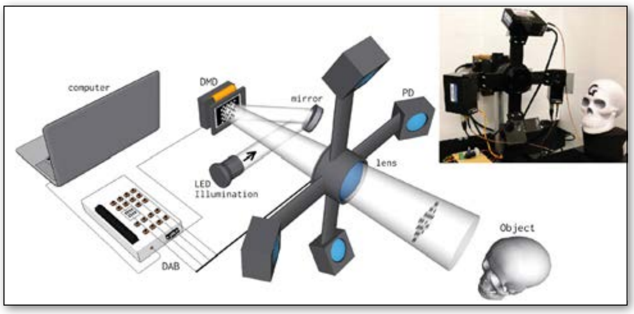
Photometric stereo is an extensively utilized 3D imaging technique, which estimates depth and surface orientation from multiple images of an object taken from the same viewpoint under different illumination directions. This approach demands the scene to remain completely static whilst changing the lighting condition in order to prevent pixel matching errors, which limits its scope in real-time applications.
The authors have been working on eliminating the underlying problems associated with sequential acquisitions. Recently, they have demonstrated a modified photometric stereo system with perfect pixel-registration, capable of reconstructing 3D images of scenes exhibiting dynamic behaviour in real-time.

The authors used four single-pixel detectors in different spatial locations to reconstruct images of a scene with different shading profiles simultaneously, exhibiting perfect pixel registration even for moving objects. To speed-up the frame rates, the authors employed a compressive strategy, known as evolutionary compressed sensing, which utilizes a particular ordered subset of Hadamard patterns instead of a complete pattern set to form images.

This method provides an alternative solution for real-time photometric stereo imaging and can be readily extended to other wavelengths, such as the infrared, where traditional camera technology is expensive. ■

■ **Y. Zhang**, **M.P. Edgar**, **B. Sun**, **N. Radwell**, **G.M. Gibson** and **M.J. Padgett**, '3D single-pixel video', *J. Opt.* **18**, 035203 (2016)

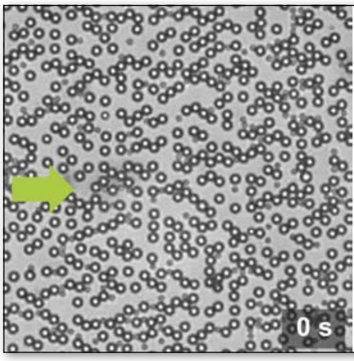
▼ Modified photometric stereo system with photodetectors.



CONDENSED MATTER

# Travelling wave drives magnetic particles

**New method for selectively controlling the motion of multiple sized microspheres suspended in water.**




◀ Optical microscope images separated by 6.63 s showing the formation of chains between only the large particles starting from an initially random mixture of two particles sizes.

As our technology downsizes, scientists often operate in microscopic-scale jungles, where modern-day explorers develop new methods for transporting microscopic objects of different sizes across non uniform environments, without losing them. Now, the authors, have developed a new method for selectively controlling, via a change in magnetic field, the aggregation or disaggregation of magnetically interacting particles of two distinct sizes in suspension in a liquid. Previous studies only focused on one particle size. These results, just published, show that it is possible to build long chains of large particles suspended in a liquid, forming channels that drive the small particles to move along. This could be helpful, for example, when sorting magnetic beads by size, separating biological or chemical entities in lab-on-a-chip devices or transporting biological species to analyse them. ■

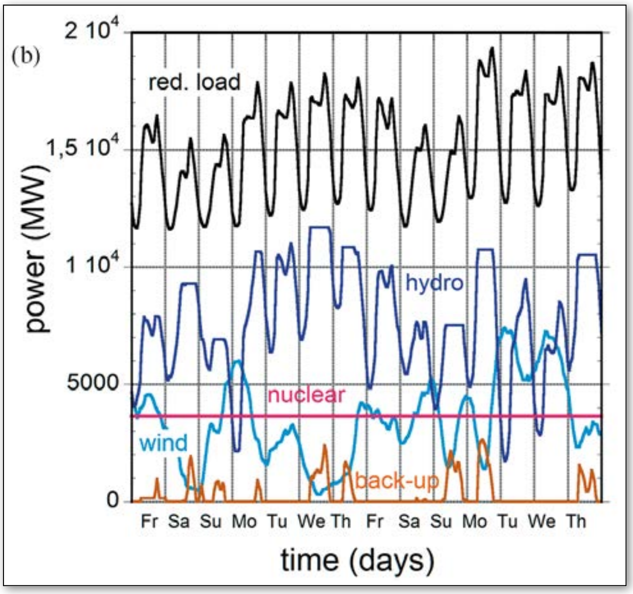
■ **P. Tierno** and **A.V. Straube**,
'Transport and selective chaining of bidisperse particles in a travelling wave potential', *Eur. Phys. J. E* **39**, 54 (2016)

ENERGY PHYSICS

# Sweden's 100% carbon-free emissions challenge

**Replacing nuclear power with wind power doesn't make sense in Sweden, study shows.**

The Swedish power supply is largely free of carbon emissions. Indeed, it is mainly based on a combination of hydroelectric and nuclear power combined with power exchange with neighbouring Scandinavian countries. A study, published recently, investigates the possibility of replacing nuclear power with wind power, which is by nature intermittent. According to the study, this, in turn, would finally lead to a reduction in the use of hydroelectricity if the annual consumption remained constant. The authors of the study conclude that a backup system, based on fossil fuel, namely gas, would be required in combination with wind power. In such a scenario, the $CO_2$ emissions would double. The authors therefore conclude that it would not be a viable option. ■




▲ The figure shows the reduced load along with the original nuclear power, the contribution of which is halved. It also shows the increased contribution from wind necessary and that from a backup system.

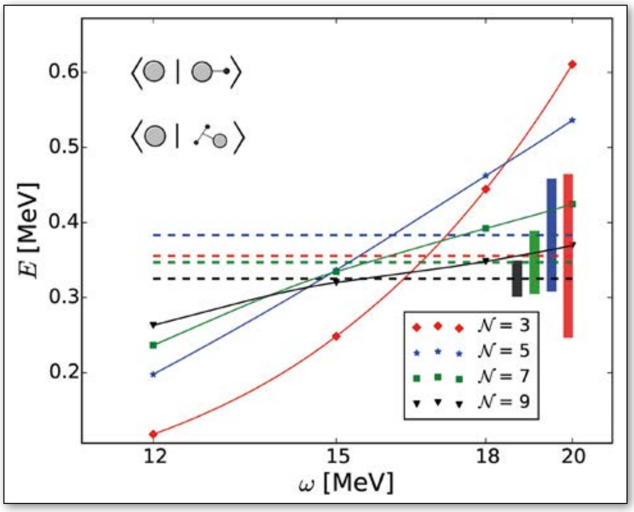
■ **F. Wagner** and **E. Rachlew**,
'Study on a hypothetical replacement of nuclear electricity by wind power in Sweden', *Eur. Phys. J. Plus* **131**, 173 (2016)

NUCLEAR PHYSICS

# New approach to nuclear structure, freely available

**Use of relative coordinates in nuclear structure calculations helps reduce the amount of computational power required.**

The atomic nucleus is highly complex. This complexity partly stems from the nuclear interactions in atomic nuclei, which induce strong correlations between the elementary particles, or nucleons, that constitute the heart of the atom. The trouble is that understanding this complexity often requires a tremendous amount of computational power. In a new study published recently, the authors propose a new approach to nuclear structure calculations. The results are freely available to the nuclear physicists' community so that other groups can perform their own nuclear structure calculations, even if they have only limited computational resources. In the new work, the authors generate sets of basis states for nucleons in complex nuclei, which




▲ Extraction of the excitation energy of the ½- state of lithium ($^{7}$Li ) using the dependence on the harmonic oscillator frequency ω.

feature anti-symmetrical relative coordinates. The study focuses on several p-shell nuclei and examines their dependence on the harmonic oscillator frequency. Subsequently, the authors extract the binding and excitation energies of these nuclei. ■

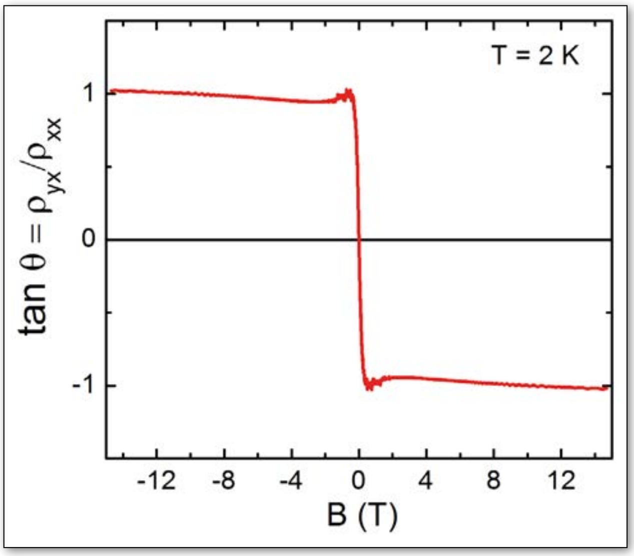
■ **S. Liebig**, **U.-G. Meißner** and **A. Nogga**,
'Jacobi no-core shell model for p-shell nuclei',
*Eur. Phys. J. A* **52**,103 (2016)

CONDENSED MATTER

## Unusual transport properties of the topological Dirac metal $Na_3Bi$

The three-dimensional (3D) topological Dirac semimetals are of strong topical interest. They display two bulk Dirac nodes that are rigorously protected against gap formation by symmetry.

▼ The Hall-angle field profile observed in the Dirac metal $Na_3Bi$.




As such, the states are massless fermions, and hence a superposition of Weyl states with distinct handedness or chirality. Breaking of the chiral symmetry in parallel magnetic and electric fields is predicted to lead to the appearance of an axial (nonpolar) current. Recently, this chiral anomaly was observed in $Na_3Bi$ as a 6-fold increase in conductance when a magnetic field $B$ is aligned parallel to the current density. Here we report that, in crystals of $Na_3Bi$ with larger Fermi energy ($E_F$~400 *vs.* 30 meV), the chiral anomaly is unresolved. Instead, we observe an unusual linear magnetoresistance (MR) that persists to 34 Tesla. The linear MR arises because the Hall conductivity $\sigma_{xy}$ and longitudinal conductivity $\sigma_{xx}$ share the same field dependence $1/B$ at large $B$. The inferred Hall angle has a striking non-Drude step-like profile (Figure). We discuss the possibility that the transport lifetime is strongly reduced by $B$. ■

■ **J. Xiong**, **S. Kushwaha**, **J. Krizan**, **T. Liang**, **R. J. Cava** and **N. P. Ong**,
'Anomalous conductivity tensor in the Dirac semimetal $Na_3Bi$', *EPL* **114**, 27002 (2016)

PLASMA PHYSICS

## Catalysis goes better with plasma

Plasma created by an electrical discharge in a gas is an effective tool for removing pollutants from waste gases and converting them into clean fuels such as hydrogen. Plasma contains a soup of species: energetic electrons, ions, excited states and free radicals. In non-thermal plasma, the electrons have a very high temperature (> 10,000K) whilst the gas remains cold. Catalysts are used widely to make chemical processes more efficient by lowering barriers to reaction, improving yields. However, many catalytic processes work at high temperatures and pressures with high energy costs and reduced catalyst lifetime.

It was discovered that placing a catalyst in a discharge, could synergistically improve the overall performance at lower temperatures and pressures with better energy efficiency and increased catalyst durability. But questions remain about the mechanism. How does the plasma affect the catalyst and how is the discharge affected by the catalyst? Which effect dominates?

This article reviews the current state of knowledge in the field (the known knowns and the known unknowns), identifies the gaps in our knowledge and suggests techniques from other fields to study plasma catalysis to generate new insight and questions (the unknown unknowns). ■

■ **J.C. Whitehead**,
'Plasma–catalysis: the known knowns, the known unknowns and the unknown unknowns',
*J. Phys. D : Appl. Phys.* **49**, 243001 (2016)

# ON THE ORIGIN OF THE COSMIC ELEMENTS AND THE NUCLEAR HISTORY OF THE UNIVERSE

Jordi José[1], Martin Asplund[2], Corinne Charbonnel[3], Isabelle Cherchneff[4], Roland Diehl[5], Andreas Korn[6] and Friedrich-Karl Thielemann[4]

[1] Technical University of Catalonia, Barcelona, Spain – [2] Australian National University, Canberra, Australia – [3] University of Geneva, Switzerland – [4] University of Basel, Switzerland – [5] Max-Planck-Institute for Extraterrestrial Physics, Garching, Germany – [6] Uppsala University, Sweden – DOI: http://dx.doi.org/10.1051/epn/2016401

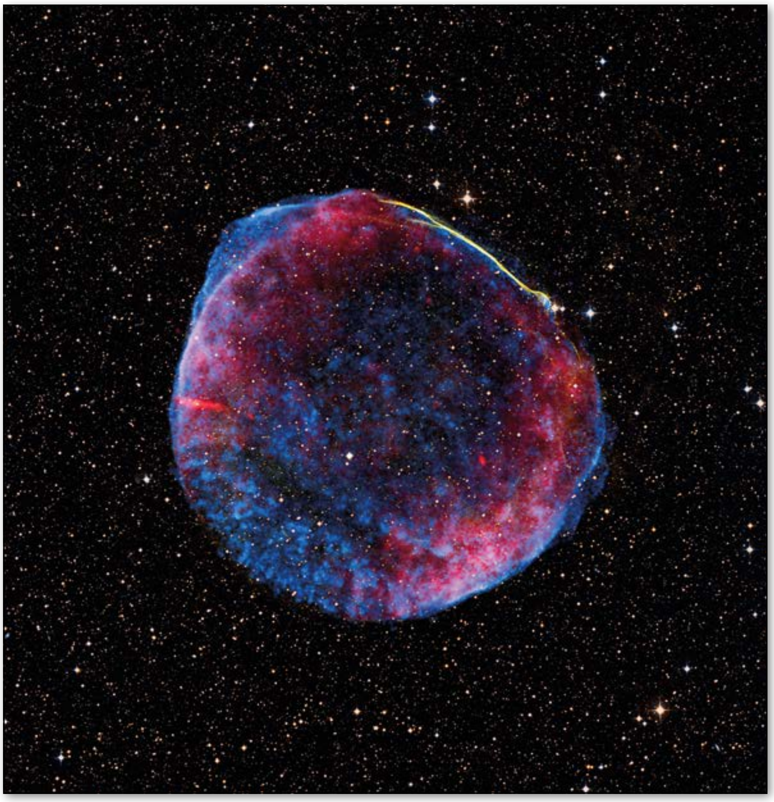
**The quest for the energy source of stars, capable of maintaining their long-lasting brightness, has puzzled physicists during centuries. Early suggestions, due to Julius R. von Mayer, John James Waterson, Hermann von Helmholtz, and William Thomson (Lord Kelvin), among others, relied on the conversion of gravitational potential energy into heat. However, the age of the Sun inferred in this framework was only a few million years, a value clearly at odds with estimates based on geological records.**

◂ P. 15: SN 1994D, a type Ia (or thermonuclear) supernova explosion spotted at the outskirts of the spiral galaxy NGC 4526. Such thermonuclear events are considered the main iron factories in the universe. Credit: NASA/ESA, The Hubble Key Project Team and The High-Z Supernova Search Team.

After the serendipitous discovery of radioactivity by Antoine H. Becquerel in 1896, the focus shifted toward nuclear energy. Following a series of atomic mass measurements, Francis W. Aston concluded in 1920 that four individual hydrogen nuclei are heavier than a helium nucleus [1]. This result led Arthur S. Eddington [2] to suggest that the energy source of the Sun lies in the conversion of hydrogen into helium, thus releasing this extra 'binding energy' deep inside the star. A major step forward in understanding the fusion of atomic nuclei was provided by experiments on Coulomb barrier penetration, performed by George Gamow [3] and Ronald W. Gurney and Edward U. Condon [4], which led Robert Atkinson and Fritz Houtermans [5] to conclude that quantum tunneling plays a key role in the energy generation in stars through nuclear fusion.

The earliest stage in the nuclear history of a star is (central) hydrogen fusion with helium as final product. Soon, two different pathways for hydrogen fusion were identified: the so-called *proton-proton chains* [6,7] and the *CNO cycle* [8,9]. This pioneering work paved the road for the first self-consistent studies of element production in stars, the so-called *nucleosynthesis theory*, by Fred Hoyle [10,11]. Equally influential was the compilation of Solar System abundances by Hans Suess and Harold Urey [12]: Plotted as a function of mass number, A, the distribution of abundances shows a complex pattern across ten orders of magnitude of abundances, with hydrogen and helium being by far the most abundant species, with a secondary peak towards iron at ~1/10000 of their abundance, and again much lower abundances for heavier elements beyond. The presence of several maxima were soon attributed to a number of nuclear physics effects, such as the existence of tightly bound nuclei (*e.g.*, $^{56}$Fe), or the role played by closed-shell configurations with magic numbers at 50, 82, and 126 nucleons.

▾ FIG. 1: Composite image of a historical supernova remnant (SN 1006), likely a type Ia supernova, located at 7100 light-years from Earth. Type Ia supernovae are prominent Fe factories in the universe. Credit: X-ray: NASA/CXC/Rutgers/G. Cassam-Chenai, J. Hughes *et al.*; Radio: NRAO/AUI/NSF/GBT/VLA/Dyer, Maddalena, and Cornwell; Optical: Middlebury College/F. Winkler, NOAO/AURA/NSF/CTIO Schmidt and DSS. Source: Wikipedia.



Stars appeared as the likely sites where most of the cosmic elements were actually being cooked, but observational evidence was as yet missing. In this regard, the detection of technetium in the spectra of several giant stars by Paul W. Merrill, in 1952, provided smoking-gun evidence to this conjecture [13]. Technetium is, in fact, the lightest element with no stable isotopes. Since its longest-lived form has a rather short half-life, $t_{1/2}[^{98}Tc]$ ~ 4.2 Myr, it was likely produced *in situ*, in the observed stars. Compared with the age of the Galaxy of more than 10 Gyrs, this proves that nucleosynthesis is still ongoing in the Universe. Two seminal papers, that provided the theoretical framework for the origin of the *chemical* species, were published shortly after, in 1957, almost exactly a century since Darwin's treatise on the origin of *biological* species: the first, by Margaret Burbidge, Geoffrey Burbidge, William A. Fowler and Fred Hoyle, in *Reviews of Modern Physics* [14], and the second, a compilation of lecture notes known as the *Chalk River report CRL-41*, by Al G.W. Cameron [15].

More than half a century later, nuclear astrophysics has flourished as a truly multidisciplinary field, aimed at understanding energy production in stars and the origin of the chemical elements in the Universe (Figure 1). New tools and developments, at the crossroads of theoretical and computational astrophysics, observational astronomy, astro- and cosmochemistry, and nuclear physics, have revolutionized our understanding of the nuclear history of the universe. The use of space-borne observatories, for instance, has opened new windows, so that we can study the cosmos through multifrequency observations. Indeed, since the last decades, UV, X- and γ-ray satellites have been used simultaneously to ground-based optical and radiotelescopes to analyze the behaviour of stars and their explosions at different wavelengths. In parallel to the elemental stellar abundances inferred spectroscopically, cosmochemists are now providing isotopic abundance ratios from micron-sized presolar grains extracted from meteorites. Encapsulated in those grains, there is pristine information about the suite of nuclear processes that took place near their condensation sites in stellar outskirts, which translate into huge isotopic anomalies with respect to bulk solar-system material. The dawn of supercomputing has also provided astrophysicists with the appropriate tools to study the complex physical phenomena of nucleosynthesis that require a truly multidimensional approach (*e.g.*, convective and radiative energy transport by photons and neutrinos, mixing of matter through flows by convection or stimulated by stellar rotation, and flame propagation in stars). Also, nuclear physicists have developed new experimental (and theoretical) techniques to determine nuclear interactions at or close to stellar energies, at the so-called Gamow window, thus reducing the problems associated with extrapolation of measurements from the higher energies that are accessible in the laboratory down to stellar energies. Moreover, they have also explored the properties of nuclei far from stability and of matter at and beyond nuclear densities.

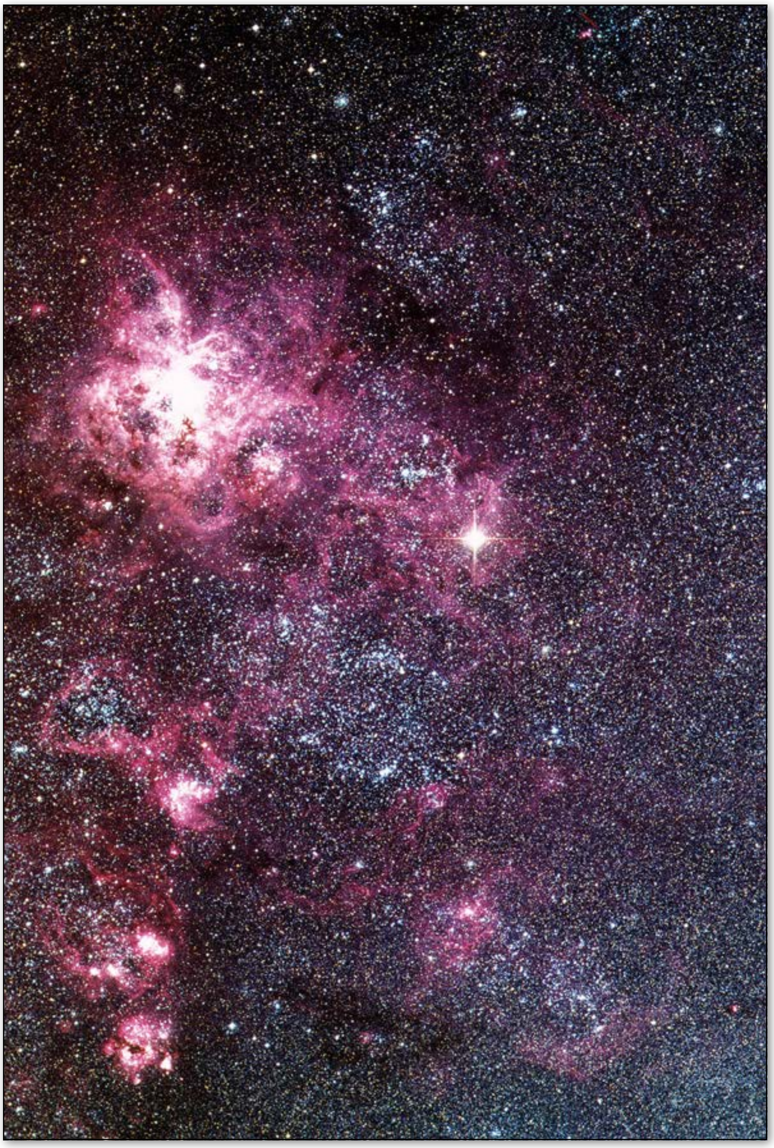
## The EuroGENESIS Program: One Step Forward

Understanding of the progress achieved in those various sub-fields of nuclear astrophysics and assessment of its current challenges require the combination of efforts in observational astronomy, cosmochemistry, computational astrophysics, and experimental and theoretical nuclear physics. In this framework, the *EuroGENESIS* Program (ESF, 2010-2013) successfully assembled about 200 specialists in these fields (from 30 research institutions and universities from 15 European countries, plus the US and Canada), into a coordinated, interdisciplinary effort aimed at understanding how matter evolved in the Universe, from the ashes of the Big Bang to its current form.

With an overall Budget estimated in 2.5 M€, EuroGENESIS was thematically arranged around four, intertwined research topics:

### 1. Nucleosynthetic fingerprints of the first stars

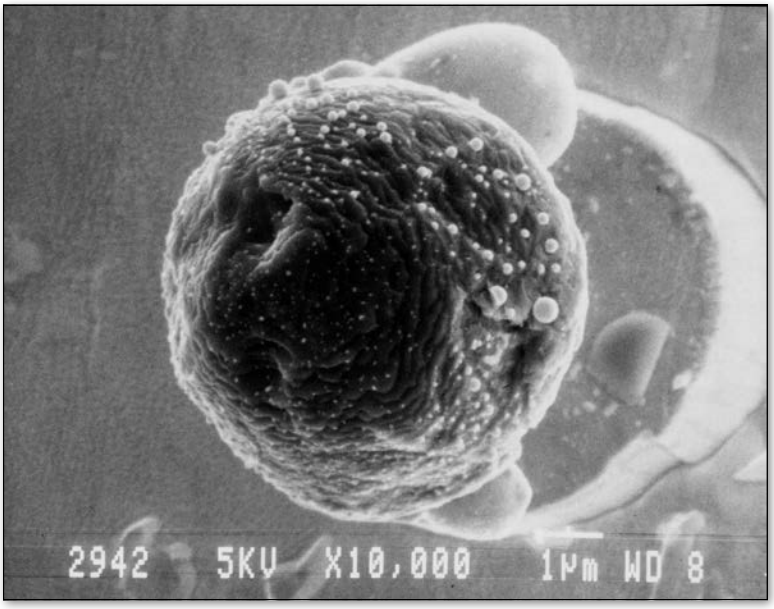
The oldest stars of the Milky Way represent a unique window to the early Universe. Searches for ever more metal-poor stars have been conducted since the 1950s (more metal-poor meaning less chemical enrichment, meaning closer to the metal-free Big Bang) and since the 2000s we know stars with 10 million times less iron than the Sun. The chemical fingerprints in the spectra of these stars trace the nucleosynthesis and physics of the very first supernovae which likely exploded a few hundred million years after the Big Bang (corresponding to a mere 1-2% of the present age of the Universe). Within this collaboration, a diverse team of experts looked at the whole chain of steps needed to understand early Galactic chemical evolution: from finding the most metal-poor and oldest stars and refining the analysis using state-of-the-art simulations of the light-emitting regions of these stars (in terms of hydrodynamic and diffusive processes), to properly interpreting the chemical make-up of these objects and of the galaxy and its substructures (in particular halo and globular clusters) by means of models of rotating stars.



▲ **FIG. 2:** **SN 1987A, the closest supernova detected since the invention of the telescope. The object corresponds to the very bright, massive star in the middle right of the Tarantula Nebula, in the Large Magellanic Cloud. At the time of this picture, SN 1987A was visible with the naked eye. Credit: ESO. Source: http://www.eso.org/public/images/eso0708a/, released into public domain by ESO.**

Among the most relevant results achieved by the different researchers of this collaboration, one could mention:

- Discovery of the most iron-deficient halo star known using the SkyMapper telescope;
- Discovery of extremely metal-poor stars in the Milky Way bulge, predicted to be the oldest stars known in the Universe;
- Work on metal-poor globular clusters showing that the surface compositions of little-evolved stars are systematically affected by atomic diffusion, lowering individual chemical abundances by up to 60%;
- Improved modelling of the $^{6}Li/^{7}Li$ ratio in metal-poor stars;
- A 300-night spectroscopic survey of the Milky Way at the Very Large Telescope;
- Study of the effects of internal gravity waves, rotation-induced mixing, and atomic diffusion on the evolution and chemical properties of metal-poor low-mass stars;




▲ FIG. 3: A number of nova and supernova candidate grains have been identified through Secondary Ion Mass Spectrometry. Image of the graphite grain KFC1a-511, courtesy of Sachiko Amari.

- Study of the nucleosynthetic signatures of the first rotating massive stars on the long-lived low-mass stars in globular clusters;
- Improved spectroscopic analysis techniques for metal-poor stars to determine their chemical compositions.

### 2. Massive stars as agents of chemical evolution

This collaboration consisted of groups with expertise in experimental and theoretical nuclear physics, stellar evolution and explosion (*e.g.*, supernovae; see Figure 2), resulting nucleosynthesis predictions, and their impact on the local environment, as well as the overall abundance evolution of galaxies. Observers from various astronomy windows as well as meteoritic studies complemented this collaboration. This led to a variety of inter-disciplinary work: Detailed comparisons of different stellar evolution codes, in order to test the treatment of mixing and other ingredients with the aim to measure the obtained convergence in our understanding of stellar evolution. Comparison of predictions with observations resulted in incentives to perform nuclear experiments (partially underground). Theoretical predictions for reactions in early and late phases of stellar evolution and explosions were tested with respect to their impact. Supernova core collapse simulations probed the nuclear equations of state and predictions for nucleosynthesis ejecta. Finally, employing these results in chemical evolution processes of the Galaxy and its building blocks, permitted to utilize a variety of astronomical constraints as a feedback for individual stellar modelling as well as the treatment of galactic evolution. The result was the formation of a community with many new and direct interactions, connecting the knowledge from nuclear reactions over stars and supernova simulations to observations of the diffuse interstellar gas and individual objects as well as their imprint in galactic evolution.

Among the large number of achievements reached in this Collaboration, a few are worth emphasising:

- A highly improved nuclear input basis has been set, from low-energy fusion reactions, n-captures, charged-particle reactions for explosive conditions (from experiment and theory), nuclear masses far from stability, fission barriers and fission fragment distributions, electron-captures and neutrino induced reactions;
- Improved understanding was obtained of uncertainties in stellar evolution, comparing different evolution codes, strong progress in modelling stellar evolution with rotation, including the effect on hydrostatic nucleosynthesis ejecta and wind composition;
- Major progress in supernova modelling and successful explosions emerged, and now we are close to being able to perform nucleosynthesis calculations in multi-D models, which – together with other observational features – can test these models and the utilized physics ingredients;
- Intermediate approaches in 1D, with the aim to mimic multi-D modelling, permitted to perform large-scale and extensive nucleosynthesis predictions which can test the effect of weak interactions on the abundance features of the innermost ejected zones;
- Understanding the r-process site (*i.e.*, the stellar factories of half of the neutron-rich nuclei heavier than iron, created through rapid neutron captures) remains a challenge, but our understanding was strongly advanced, addressing in great detail neutrino winds, jets from fast rotating, highly magnetized core collapse supernovae, and neutron star mergers, and performing also tests of these sites with their impact on galactic chemical evolution.

### 3. Cosmic dust grains as diagnostic for massive stars

This was a multidisciplinary collaboration, whose objectives were to advance knowledge of the formation of cosmic dust in supernovae, the reprocessing of dust in supernova remnants, and the chemical seeding with isotopes and dust of the interstellar medium and the solar nebula by supernovae. The collaboration uniquely gathered several research groups from four different fields of astrophysics (astrochemistry, astronomy, experimental physics of meteorites and nuclear physics) and delivered several important outcomes on the production of dust by core-collapse supernovae. The collaboration successfully delivered the following results:

- Core-collapse supernovae are significant producers of several dust components (silicates, alumina, carbon, silicon carbide, pure metals and iron grains) locally and in the early universe. The formation of dust goes along with the synthesis of simple molecules in the ejected material, such as CO, SiO, SO and SiS. The recent detection of molecules with the Atacama Large Millimetre Array, ALMA, in the young supernova remnant SN1987A has confirmed these predictions. The production of dust occurs in various zones of the ejected material a few months after the supernova explosion and the dust mass gradually increases over a period of five years from small values ($10^{-4}$ solar masses) to large values (0.1 solar masses). This gradual growth provides a possible explanation for the discrepancy between the small amounts of dust formed at early post-explosion times and the high dust masses derived from recent observations of supernova remnants like SN1987A, Cassiopeia A and the Crab nebula;

- Sputtering of dust by shocks in the remnant phase is highly dependent on the clumpiness of the gas in the remnant. Large dust grains (> 0.1 microns; see Figure 3) survive shocks and can be injected in the interstellar medium. These grains will finish their life in proto-stellar nebula and be incorporated in meteorites in the solar nebula. Observation time on the space telescope Herschel was obtained to study dense gas clumps rich in molecules and dust in the supernova remnant Cassiopeia A. These observations confirmed the existence of molecules formed in the supernova that are later shocked in the remnant, with the detection of warm CO emission lines;
- A sample of a deep-sea manganese crust that showed the $^{60}$Fe "supernova- signal" was searched for live $^{244}$Pu, and revealed unexpected low fluxes. This finding indicates that no significant actinide nucleosynthesis happened within the last few hundred million years. This is incompatible with normal actinide production in supernovae and suggests that a rare event rate, *i.e.*, a small subset of supernovae or neutron-star mergers, has seeded the solar nebula.

## 4. Physics of compact objects: explosive nucleosynthesis and evolution

Many stars form binary or multiple systems, with a fraction hosting one or two degenerate objects (white dwarfs and/or neutron stars) in short-period orbits, such that mass transfer episodes onto the degenerate component ensue. This scenario is the framework for a suite of violent stellar events, such as type Ia supernovae, classical novae, X-ray bursts, or stellar mergers (involving white dwarfs, neutron stars and black holes). The expected nucleosynthesis accompanying these cataclysmic events is very rich: classical novae are driven by proton-capture reactions in competition with β-decays, proceeding close to the valley of stability, up to Ca. Type I X-ray bursts are powered by a suite of nuclear processes, including the rp-process (rapid p-captures and β-decays), the 3α-reaction, and the αp-process (a sequence of (α,p) and (p,γ) reactions); here, the nuclear flow proceeds far away from the valley of stability, merging with the proton drip-line beyond A = 38, and reaching eventually the SnSbTe-mass region, or beyond. In type Ia supernovae, the detailed abundances of the freshly synthesized elements depend on the peak temperature

> **The experience achieved in the multi-national, multi-institute EuroGENESIS project has built and organized a European Community in the wide field of nuclear astrophysics.**

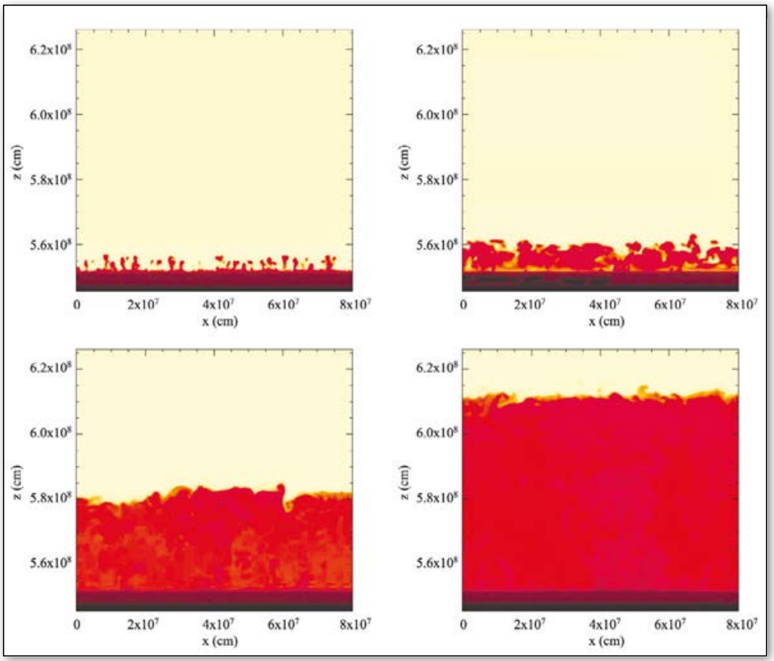
reached and on the excess of neutrons and protons (which depend in turn on the metallicity of the white dwarf progenitor as well as on the density at which the thermonuclear runaway occurs); they constitute the major factory of Fe-peak elements in the Galaxy, and roughly speaking, the abundance pattern of their ejecta is the result of four different burning regimes: nuclear statistical equilibrium (NSE) and incomplete Si-, O-, and C-Ne-burning. A suite of different nuclear processes are expected to occur during stellar mergers (indeed, neutron star mergers have been suggested as a possible site for the r-process).

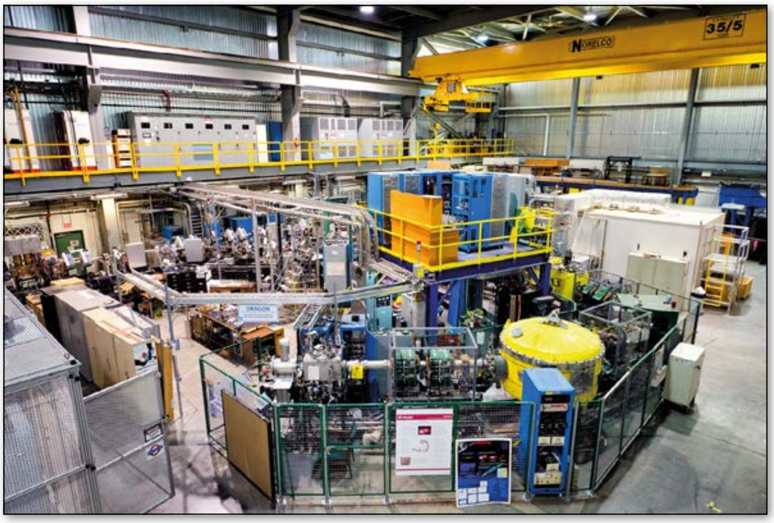
This collaboration consisted of groups with expertise in experimental and theoretical nuclear physics, computational hydrodynamics (with emphasis in multidimensional simulations of stellar explosions and on their associated high-energy emission in X- and gamma-rays), and cosmochemistry (through laboratory analysis of presolar grains), from 11 institutions.

Among the most relevant results achieved in this area by the different components of the Collaboration, one could mention:

- 3-D simulations of nucleosynthesis accompanying double white dwarf mergers, with emphasis on

▼FIG. 4: Two-dimensional snapshots of the development of hydrodynamic instabilities, in a 3-D simulation of mixing at the core-envelope interface during a nova explosion, calculated with the hydrodynamic code FLASH (adapted from Casanova *et al.* 2011, Nature, 478, 490).






▲ **FIG. 5:** DRAGON, an example of recoil mass separator for the study of nuclear reactions of astrophysical interest, located in the ISAC facility at TRIUMF (Vancouver). Image courtesy of Steven Oates.

Li production and on the origin of R Cor Bor stars (a variety of hydrogen-deficient stars with high carbon abundances);

- New nuclear reaction-rate compilation based on Monte Carlo method. Improvements on a suite of reaction rates of interest for nova nucleosynthesis;
- First 3-D simulation of mixing at the core-envelope interface during nova outbursts (Figure 4);
- Identification of a number of oxide grains of a putative nova origin;
- Identification of the most relevant nuclear uncertainties affecting type Ia supernova and type I X-ray burst nucleosynthesis predictions.

## Conclusion

The experience achieved in the multi-national, multi-institute EuroGENESIS project has built and organized a European Community in the wide field of nuclear astrophysics. It led to new and effective interactions and information flow across the scattered and widely-spread and individually-small research groups of nuclear physics experimentalists (Figure 5), theorists, modellers and astrophysical observers. This permitted joint rather than isolated actions. It probably laid the ground work for future joint explorations at a trans-national level, necessary to make break-through advances in such a complex and inter-related field that spans from the microcosmos of nuclear forces to the macroscopic cosmic objects and the chemical evolution across the entire universe. ■

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## References


[1] F.W. Aston, *Philosophical Magazine* **39**, 611 (1920).

[2] A.S. Eddington, *Observatory* **43**, 341 (1920).

[3] G. Gamow, *Zeitschrift für Physik* **51**, 204 (1928).

[4] R.W. Gurney and E.U. Condon, *Physical Review* **33**, 127 (1929).

[5] R. d'E. Atkinson and F.G. Houtermans, *Zeitschrift für Physik* **54**, 656 (1929).

[6] R. d'E. Atkinson, *The Astrophysical Journal* **84**, 73 (1936).

[7] H.A. Bethe and C.L. Critchfield, *Physical Review* **54**, 248 (1938).

[8] C.F. von Weizsäcker, *Physikalische Zeitschrift* **39**, 633 (1938).

[9] H.A. Bethe, *Physical Review* **55**, 434 (1939).

[10] F. Hoyle, *Monthly Notices of the Royal Astronomical Society* **106**, 343 (1946).

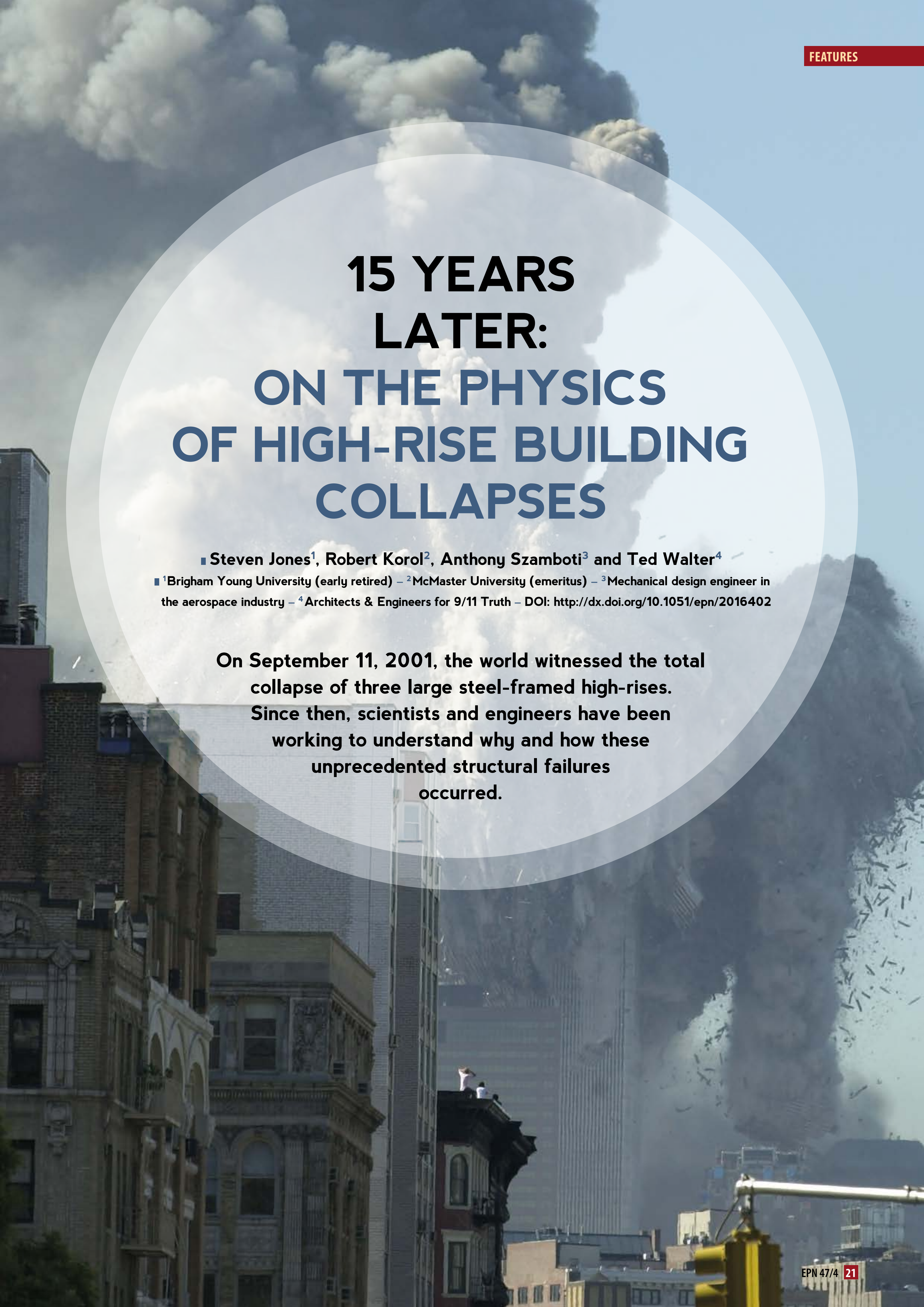
[11] F. Hoyle, *The Astrophysical Journal Supplement Series* 1, 121 (1954).

[12] H.E. Suess and H.C. Urey, *Reviews of Modern Physics* **28**, 53 (1956).

[13] P.W. Merrill, *The Astrophysical Journal* **116**, 21 (1952).

[14] E.M. Burbidge, G.R. Burbidge, W.A. Fowler, and F. Hoyle, *Reviews of Modern Physics* **29**, 547 (1957).

[15] A.G.W. Cameron, *Stellar Evolution, Nuclear Astrophysics, and Nucleogenesis*. 2nd Ed., Dover Publications, Mineola, New York (2013).



# 15 YEARS LATER: ON THE PHYSICS OF HIGH-RISE BUILDING COLLAPSES

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**On September 11, 2001, the world witnessed the total collapse of three large steel-framed high-rises. Since then, scientists and engineers have been working to understand why and how these unprecedented structural failures occurred.**

## NOTE FROM THE EDITORS

This feature is somewhat different from our usual purely scientific articles, in that it contains some speculation. However, given the timing and the importance of the issue, we consider that this feature is sufficiently technical and interesting to merit publication for our readers. Obviously, the content of this article is the responsibility of the authors.

In August 2002, the U.S. National Institute of Standards and Technology (NIST) launched what would become a six-year investigation of the three building failures that occurred on September 11, 2001 (9/11): the well-known collapses of the World Trade Center (WTC) Twin Towers that morning and the lesser-known collapse late that afternoon of the 47-story World Trade Center Building 7, which was not struck by an airplane. NIST conducted its investigation based on the stated premise that the "WTC Towers and WTC 7 [were] the only known cases of total structural collapse in high-rise buildings where fires played a significant role."

Indeed, neither before nor since 9/11 have fires caused the total collapse of a steel-framed high-rise—nor has any other natural event, with the exception of the 1985 Mexico City earthquake, which toppled a 21-story office building. Otherwise, the only phenomenon capable of collapsing such buildings completely has been by way of a procedure known as controlled demolition, whereby explosives or other devices are used to bring down a structure intentionally. Although NIST finally concluded after several years of investigation that all three collapses on 9/11 were due primarily to fires, fifteen years after the event a growing number of architects, engineers, and scientists are unconvinced by that explanation.

### Preventing high-rise failures

Steel-framed high-rises have endured large fires without suffering total collapse for four main reasons:
**1)** Fires typically are not hot enough and do not last long enough in any single area to generate enough energy to heat the large structural members to the point where they fail (the temperature at which structural steel loses enough strength to fail is dependent on the factor of safety used in the design. In the case of WTC 7, for example, the factor of safety was generally 3 or higher. Here, 67% of the strength would need to be lost for failure to ensue, which would require the steel to be heated to about 660°C);
**2)** Most high-rises have fire suppression systems (water sprinklers), which further prevent a fire from releasing sufficient energy to heat the steel to a critical failure state;
**3)** Structural members are protected by fireproofing materials, which are designed to prevent them from reaching failure temperatures within specified time periods; and
**4)** Steel-framed high-rises are designed to be highly redundant structural systems. Thus, if a localized failure occurs, it does not result in a disproportionate collapse of the entire structure.

Throughout history, three steel-framed high-rises are known to have suffered partial collapses due to fires; none of those led to a total collapse. Countless other steel-framed high-rises have experienced large, long-lasting fires without suffering either partial or total collapse (see, for example, Fig. 1a and 1b) [1].

In addition to resisting ever-present gravity loads and occasional fires, high-rises must be designed to resist loads generated during other extreme events—in particular, high winds and earthquakes. Designing for high-wind and seismic events mainly requires the ability of the structure to resist lateral loads, which generate both tensile and compressive stresses in the columns due to bending, the latter stresses then being combined with gravity-induced compressive stresses due to vertical loads. It was not until steel became widely manufactured that the ability to resist large lateral loads was achieved and the construction of high-rises became possible. Steel is both very strong and ductile, which allows it to withstand the tensile stresses generated by lateral loads, unlike brittle materials, such as concrete, that are weak in tension. Although concrete is used in some high-rises today, steel reinforcement is needed in virtually all cases.

To allow for the resistance of lateral loads, high-rises are often designed such that the percentage of their columns' load capacity used for gravity loads is relatively

▼ **FIG. 1:** WTC 5 is an example of how steel-framed high-rises typically perform in large fires. It burned for over eight hours on September 11, 2001, and did not suffer a total collapse (Source: FEMA).

▲ **FIG. 2:** WTC 7 fell symmetrically and at free-fall acceleration for a period of 2.25 seconds of its collapse (Source: NIST).

low. The exterior columns of the Twin Towers, for example, used only about 20% of their capacity to withstand gravity loads, leaving a large margin for the additional lateral loads that occur during high-wind and seismic events [2].

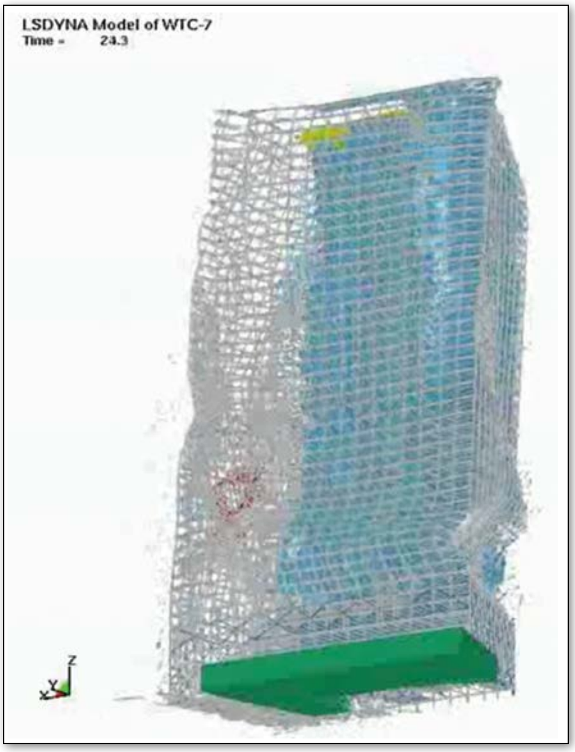
Because the only loads present on 9/11 after the impact of the airplanes were gravity and fire (there were no high winds that day), many engineers were surprised that the Twin Towers completely collapsed. The towers, in fact, had been designed specifically to withstand the impact of a jetliner, as the head structural engineer, John Skilling, explained in an interview with the *Seattle Times* following the 1993 World Trade Center bombing: "Our analysis indicated the biggest problem would be the fact that all the fuel (from the airplane) would dump into the building. There would be a horrendous fire. A lot of people would be killed," he said. "The building structure would still be there." Skilling went on to say he didn't think a single 200-pound [90-kg] car bomb would topple or do major structural damage to either of the Twin Towers. "However," he added, "I'm not saying that properly applied explosives—shaped explosives—of that magnitude could not do a tremendous amount of damage.... I would imagine that if you took the top expert in that type of work and gave him the assignment of bringing these buildings down with explosives, I would bet that he could do it."

In other words, Skilling believed the only mechanism that could bring down the Twin Towers was controlled demolition.

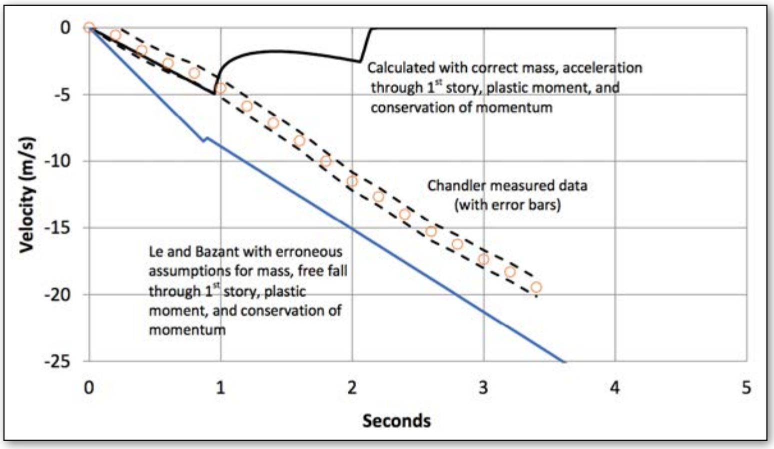
## Techniques of controlled demolition

Controlled demolition is not a new practice. For years it was predominantly done with cranes swinging heavy iron balls to simply break buildings into small pieces. Occasionally, there were structures that could not be brought down this way. In 1935, the two 191-m-tall Sky Ride towers of the 1933 World's Fair in Chicago were demolished with 680 kg of thermite and 58 kg of dynamite. Thermite is an incendiary containing a metal powder fuel (most commonly aluminum) and a metal oxide (most commonly iron(III) oxide or "rust"). Eventually, when there were enough large steel-framed buildings that needed to be brought down more efficiently and inexpensively, the use of shaped cutter charges became the norm. Because shaped charges have the ability to focus explosive energy, they can be placed so as to diagonally cut through steel columns quickly and reliably.

In general, the technique used to demolish large buildings involves cutting the columns in a large enough area of the building to cause the intact portion above that area to fall and crush itself as well as crush whatever remains below it. This technique can be done in an even more sophisticated way, by timing the charges to go off in a sequence so that the columns closest to the center are destroyed first. The failure of the interior columns creates an inward pull on the exterior and causes the majority of the building to be pulled inward and downward while materials are being crushed, thus keeping the crushed materials in a somewhat confined area—often within the building's "footprint." This method is often referred to as "implosion."




◂ **FIG. 3:** The final frame of NIST's WTC 7 computer model shows large deformations to the exterior not observed in the videos (Source: NIST).




▲ **FIG. 4:** The above graph [10] compares David Chandler's measurement [9] of the velocity of the roofline of WTC 1 with Bažant's erroneous calculation [11] and with Szamboti and Johns' calculation using corrected input values for mass, acceleration through the first story, conservation of momentum, and plastic moment (the maximum bending moment a structural section can withstand). The calculations show that—in the absence of explosives—the upper section of WTC 1 would have arrested after falling for two stories (Source: Ref. [10]).

## The case of WTC 7

The total collapse of WTC 7 at 5:20 PM on 9/11, shown in Fig. 2, is remarkable because it exemplified all the signature features of an implosion: The building dropped in absolute free fall for the first 2.25 seconds of its descent over a distance of 32 meters or eight stories [3]. Its transition from stasis to free fall was sudden, occurring in approximately one-half second. It fell symmetrically straight down. Its steel frame was almost entirely dismembered and deposited mostly inside the building's footprint, while most of its concrete was pulverized into tiny particles. Finally, the collapse was rapid, occurring in less than seven seconds.

Given the nature of the collapse, any investigation adhering to the scientific method should have seriously considered the controlled demolition hypothesis, if not started with it. Instead, NIST (as well as the Federal Emergency Management Agency (FEMA), which conducted a preliminary study prior to the NIST investigation) began with the predetermined conclusion that the collapse was caused by fires.

Trying to prove this predetermined conclusion was apparently difficult. FEMA's nine-month study concluded by saying, "The specifics of the fires in WTC 7 and how they caused the building to collapse remain unknown at this time. Although the total diesel fuel on the premises contained massive potential energy, the best hypothesis has only a low probability of occurrence." NIST, meanwhile, had to postpone the release of its WTC 7 report from mid-2005 to November 2008. As late as March 2006, NIST's lead investigator, Dr. Shyam Sunder, was quoted as saying, "Truthfully, I don't really know. We've had trouble getting a handle on building No. 7."

All the while, NIST was steadfast in ignoring evidence that conflicted with its predetermined conclusion. The most notable example was its attempt to deny that WTC 7 underwent free fall. When pressed about that matter during a technical briefing, Dr. Sunder dismissed it by saying, "[A] free-fall time would be an object that has no structural components below it." But in the case of WTC 7, he claimed, "there was structural resistance that was provided." Only after being challenged by high school physics teacher David Chandler and by physics professor Steven Jones (one of the authors of this article), who had measured the fall on video, did NIST acknowledge a 2.25-second period of free fall in its final report. Yet NIST's computer model shows no such period of free fall, nor did NIST attempt to explain how WTC 7 could have had "no structural components below it" for eight stories.

Instead, NIST's final report provides an elaborate scenario involving an unprecedented failure mechanism: the thermal expansion of floor beams pushing an adjoining girder off its seat. The alleged walk-off of this girder then supposedly caused an eight-floor cascade of floor failures, which, combined with the failure of two other girder connections—also due to thermal expansion—left a key column unsupported over nine stories, causing it to buckle. This single column failure allegedly precipitated the collapse of the entire interior structure, leaving the exterior unsupported as a hollow shell. The exterior columns then allegedly buckled over a two-second period and the entire exterior fell simultaneously as a unit [3].

NIST was able to arrive at this scenario only by omitting or misrepresenting critical structural features in its computer modelling.[4] Correcting just one of these errors renders NIST's collapse initiation indisputably impossible. Yet even with errors that were favorable to its predetermined conclusion, NIST's computer model (see Fig. 3) fails to replicate the observed collapse, instead showing large deformations to the exterior that are not observed in the videos and showing no period of free fall. Also, the model terminates, without explanation, less than two seconds into the seven-second collapse. Unfortunately, NIST's computer modelling cannot be independently verified because NIST has refused to release a large portion of its modelling data on the basis that doing so "might jeopardize public safety."

## The case of the Twin Towers

Whereas NIST did attempt to analyze and model the collapse of WTC 7, it did not do so in the case of the Twin Towers. In NIST's own words, "The focus of the investigation was on the sequence of events from the instant of aircraft impact to the initiation of collapse for each tower….this sequence is referred to as the 'probable collapse sequence,' although it includes little analysis of the structural behaviour of the tower after the conditions for collapse initiation were reached and collapse became inevitable." [5]

Thus, the definitive report on the collapse of the Twin Towers contains no analysis of why the lower sections failed to arrest or even slow the descent of the upper sections—which NIST acknowledges "came down essentially in free fall" [5-6]—nor does it explain the various other phenomena observed during the collapses. When a group of petitioners filed a formal Request for Correction asking NIST to perform such analysis, NIST replied that it was "unable to provide a full explanation of the total collapse" because "the computer models [were] not able to converge on a solution."

However, NIST did do one thing in an attempt to substantiate its assertion that the lower floors would not be able to arrest or slow the descent of the upper sections in a gravity-driven collapse. On page 323 of NCSTAR 1-6, NIST cited a paper by civil engineering professor Zdeněk Bažant and his graduate student, Yong Zhou, that was published in January 2002 [7] which, according to NIST, "addressed the question of why a total collapse occurred" (as if that question were naturally outside the scope of its own investigation). In their paper, Bažant and Zhou claimed there would have been a powerful jolt when the falling upper section impacted the lower section, causing an amplified load sufficient to initiate buckling in the columns. They also claimed that the gravitational energy would have been 8.4 times the energy dissipation capacity of the columns during buckling.

In the years since, researchers have measured the descent of WTC 1's upper section and found that it never decelerated—*i.e.*, there was no powerful jolt [8-9]. Researchers have also criticized Bažant's use of free-fall acceleration through the first story of the collapse, when measurements show it was actually roughly half of gravitational acceleration [2]. After falling for one story, the measurements show a 6.1 m/s velocity instead of the 8.5 m/s velocity that would be the result of free fall. This difference in velocity effectively doubles the kinetic energy, because it is a function of the square of the velocity. In addition, researchers have demonstrated that the $58 \times 10^6$ kg mass Bažant used for the upper section's mass was the maximum design load—not the actual $33 \times 10^6$ kg service load [10]. Together, these two errors embellished the kinetic energy of the falling mass by 3.4 times. In addition, it has been shown that the column energy dissipation capacity used by Bažant was at least 3 times too low [2].

In January 2011 [11] Bažant and another graduate student of his, Jia-Liang Le, attempted to dismiss the lack-of-deceleration criticism by claiming there would be a velocity loss of only about 3%, which would be too small to be observed by the camera resolution. Le and Bažant also claimed conservation-of-momentum velocity loss would be only 1.1%. However, it appears that Le and Bažant erroneously used an upper section mass of $54.18 \times 10^6$ kg and an impacted floor mass of just $0.627 \times 10^6$ kg, which contradicted the floor mass of $3.87 \times 10^6$ kg Bažant had used in earlier papers. The former floor mass is representative of the concrete floor slab only, whereas the latter floor mass includes all the other materials on the floor. Correcting this alone increases the conservation-of-momentum velocity loss by more than 6 times, to a value of 7.1%. Additionally, the column energy dissipation has been shown to be far more significant than Bažant claimed. Researchers have since provided calculations showing that a natural collapse over one story would not only decelerate, but would actually arrest after one or two stories of fall (see Fig. 4) [2, 10].

## Other evidence unexplained

The collapse mechanics discussed above are only a fraction of the available evidence indicating that the airplane impacts and ensuing fires did not cause the collapse of the Twin Towers. Videos show that the upper section of each tower disintegrated within the first four seconds of collapse. After that point, not a single video shows the upper sections that purportedly descended all the way to the ground before being crushed. Videos and photographs also show numerous high-velocity bursts of debris being ejected from point-like sources (see Fig. 5). NIST refers to these as "puffs of smoke" but fails to properly analyze them [6]. NIST also provides no explanation for the midair pulverization of most of the towers' concrete, the near-total dismemberment of their steel frames, or the ejection of those materials up to 150 meters in all directions.

NIST sidesteps the well-documented presence of molten metal throughout the debris field and asserts that the orange molten metal seen pouring out of WTC 2 for the seven minutes before its collapse was aluminum from the aircraft combined with organic materials (see Fig. 6) [6]. Yet experiments have shown that molten aluminum, even when mixed with organic materials, has a silvery appearance—thus suggesting that the orange molten metal was instead emanating from a thermite reaction being used to weaken the structure [12]. Meanwhile, unreacted nano-thermitic material has since been discovered in multiple independent WTC dust samples [13].

◂ **FIG. 5:** High-velocity bursts of debris, or "squibs," were ejected from point-like sources in WTC 1 and WTC 2, as many as 20 to 30 stories below the collapse front (Source: Noah K. Murray).


▸ **FIG. 6:** Molten metal was seen pouring out of WTC 2 continuously for the seven minutes leading up to its collapse (Sources: WABC-TV, NIST).

As for eyewitness accounts, some 156 witnesses, including 135 first responders, have been documented as saying that they saw, heard, and/or felt explosions prior to and/or during the collapses [14]. That the Twin Towers were brought down with explosives appears to have been the initial prevailing view among most first responders. "I thought it was exploding, actually," said John Coyle, a fire marshal. "Everyone I think at that point still thought these things were blown up" [15].

## Conclusion

It bears repeating that fires have never caused the total collapse of a steel-framed high-rise before or since 9/11. Did we witness an unprecedented event three separate times on September 11, 2001? The NIST reports, which attempted to support that unlikely conclusion, fail to persuade a growing number of architects, engineers, and scientists. Instead, the evidence points overwhelmingly to the conclusion that all three buildings were destroyed by controlled demolition. Given the far-reaching implications, it is morally imperative that this hypothesis be the subject of a truly scientific and impartial investigation by responsible authorities. ■

## About the Authors

**Steven Jones** is a former full professor of physics at Brigham Young University. His major research interests have been in the areas of fusion, solar energy, and archaeometry. He has authored or co-authored a number of papers documenting evidence of extremely high temperatures during the WTC destruction and evidence of unreacted nano-thermitic material in the WTC dust.

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**Ted Walter** is the director of strategy and development for Architects & Engineers for 9/11 Truth (AE911Truth), a nonprofit organization that today represents more than 2,500 architects and engineers. In 2015, he authored AE911Truth's *Beyond Misinformation: What Science Says About the Destruction of World Trade Center Buildings 1, 2, and 7*. He holds a Master of Public Policy degree from the University of California, Berkeley.

## References

[1] NIST: *Analysis of Needs and Existing Capabilities for Full-Scale Fire Resistance Testing* (October 2008).

[2] G. Szuladziński and A. Szamboti and R. Johns, *International Journal of Protective Structures* **4**, 117 (2013).

[3] NIST: *Final Report on the Collapse of World Trade Center Building 7, Federal Building and Fire Safety Investigation of the World Trade Center Disaster (November* 20, 2008).

[4] R. Brookman, *A Discussion of 'Analysis of Structural Response of WTC 7 to Fire and Sequential Failures Leading to Collapse*, Journal of 9/11 Studies (October 2012).

[5] NIST: *Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers* (December 1, 2005).

[6] NIST: *Questions and Answers about the NIST WTC Towers Investigation* (Updated September 19, 2011).

[7] Z. Bažant, Y. Zhou, Yong, *Journal of Engineering Mechanics* **128**, 2 (2002).

[8] A. Szamboti and G. MacQueen, *The Missing Jolt: A Simple Refutation of the NIST-Bažant Collapse Hypothesis*, Journal of 9/11 Studies (April 2009).

[9] D. Chandler, *The Destruction of the World Trade Center North Tower and Fundamental Physics*, Journal of 9/11 Studies (February 2010).

[10] A. Szamboti and R. Johns, *ASCE Journals Refuse to Correct Fraudulent Paper Published on WTC Collapses*, Journal of 9/11 Studies (September 2014).

[11] J.-L. Le and Z. Bažant, *Journal of Engineering Mechanics* **137**, 82 (2011).

[12] S. Jones, *Why Indeed Did the WTC Buildings Collapse Completely?* Journal of 9/11 Studies (September 2006).

[13] N. Harrit *et al.*, *Open Chemical Physics Journal* (April 2009).

[14] G. MacQueen, *Eyewitness Evidence of Explosions in the Twin Towers*, Chapter Eight, The 9/11 Toronto Report, Editor: James Gourley (November 2012).

[15] Fire Department of New York (FDNY): *World Trade Center Task Force Interviews*, The New York Times (October 2001 to January 2002).

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# We shoot a bullet vertically. Where will it land?

This seems a trivial question, but we must consider the rotation of the Earth. For small elevations (small initial velocities $v_0$), given the Earth's large radius, the motion of the Earth's surface can be considered to have a constant speed, and the projectile falls back on the point of launch.

But what happens if one increases $v_0$? Is the landing point affected by the rotation of the Earth?

It is not easy to answer this question without doing the calculations. We can try to make some qualitative considerations, assuming the launching pad to be near the Equator. The projectile maintains its tangential velocity $\omega R_0$ (where $R_0$ is the radius of the Earth and $\omega$ is the angular velocity of the rotation), but climbing up it "falls behind" with respect to the tangential velocity of the altitude reached, and therefore, during the upward motion, it deviates towards the West (for the same reason why the falling bodies deviate eastward). But on its way down the opposite happens, and it is unclear whether this is enough to have the bullet land at the starting point.

Another consideration is that the projectile motion is similar to the motion of a Foucault pendulum, whose trajectories have the form of rosettes, preceding towards the West. But even this is

not enough to allow us to decide where the landing spot is. We have to resort to equations, which fortunately are not very difficult to handle (see Box).

Naively one may expect a shift towards the West [1, 2], because the Earth will rotate during the flight time of the bullet, 200 seconds in this example. In this naïve picture, the bullet would be assumed to be fired purely vertically, without initial horizontal velocity (in the inertial reference frame). Following this reasoning, the bullet is bound to land West of the launching spot.

The equations show that, indeed, there is a shift to the West. However, it is of a very different nature and magnitude if compared to the naïve result: the tangential velocity of the Earth is 437 m/s, so, following the naïve picture, in 200 seconds the bullet would land about 87 km towards the West. In reality it is only 1 km, as shown in the Box.

For more details, see Ref. [2]. ■

## References


[1] https://youtu.be/-9Jp_XCvVto

[2] Franco Bagnoli and Francesco Saverio Cataliotti, *Giornale di Fisica vol* **XII**, 103 (2001) doi:10.1393/gdf/i2011-10135-9


## BOX

We proceed in the accelerated reference frame of the Earth. We can neglect the centrifugal force, which does nothing but diminish $g$. Inserting gravity (which we shall consider constant, for not too large elevations, say a maximum of a few kilometers) and the Coriolis force we get the following two equations for the horizontal coordinate $x$ (axis tangential to the Equator, positive direction towards the West) and the elevation coordinate $z$:

$$m\ddot{x} = 2m\omega\dot{z}, \qquad (1)$$

$$m\ddot{z} = -mg - 2m\omega\dot{x}, \qquad (2)$$

where $m$ is the bullet's mass. We can integrate Eq. (1) from 0 (starting point $x(0) = z(0) = 0$, with $\dot{z}(0) = v_0$ and $\dot{x}(0) = 0$) to $t$, yielding

$$\dot{x} = 2\omega z, \qquad (3)$$

which tells us that the horizontal motion of the projectile is always directed towards the West. Obviously, the bullet will not fall on the starting point! Substituting Eq. (3) into Eq. (2) we get

$$\ddot{z} = -g - 4\omega^2 z. \qquad (4)$$

This means that the vertical motion is harmonic, which may be a bit surprising (but obvious if we remember the Foucault pendulum). By replacing the starting conditions in the solution of Eq. (4) we obtain

$$z(t) = \frac{g}{4\omega^2}[\cos(2\omega t) - 1] + \frac{v_0}{2\omega}\sin(2\omega t) \qquad (5)$$

which, as anticipated, represents a harmonic oscillation centered in $z(t) = \frac{g}{4\omega^2}$, actually below ground.

To check the plausibility of this solution, let's look at what happens in the limit $\omega \to 0$: we get $z(t) = v_0 t - \frac{1}{2} g t^2$, the standard free-fall accelerated motion. From here we can obtain an approximation for the flight time $\tau = \frac{2v_0}{g}$. Substituting Eq. (5) into Eq. (3) and integrating, we obtain

$$x(t) = \frac{g}{4\omega^2}[\sin(2\omega t) - 2\omega t] + \frac{v_0}{2\omega}[\cos(2\omega t) - 1] \qquad (6)$$

and in the limit $\omega \to 0$ we have $x(t) = 0$, as expected. In the next (third) order, we obtain

$$x(t) \simeq \omega(v_0 t^2 - \tfrac{1}{3} g t^3) \qquad (7)$$

Substituting the flight time $\tau = \frac{2v_0}{g}$ we get

$$x(\tau) = \frac{4\omega v_0^3}{3g^2} \qquad (8)$$

Inserting the rotation of the Earth, $\omega = 7.27 \cdot 10^{-5}$ rad/s (assuming to be at the Equator), and $v_0 = 1000$ m/s (not unattainable speed with a good gun), we get a maximum height of 50 km (always neglecting the air resistance!, still small compared to the Earth's radius of 6000 km), a flight time $\tau = 200$ s and a deviation towards the West of 1 km.

In the presence of the air, the calculation is much more difficult. We cannot assume that the laws of laminar viscous motion apply, since at such speeds the motion will certainly be turbulent. But the bullet should quickly get to such heights that the air density is very low (above 10 km). We therefore expect that the bullet will fall at an intermediate distance from the starting point, again towards the West.

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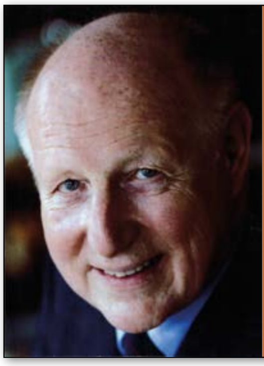

# Opinion: announcing breakthroughs and "Science Etiquette"

**Martin C.E. Huber is adjunct professor emeritus of ETH Zurich, a former Head of ESA's Space Science Department and also a former EPS President.**

The first direct detection of gravitational waves a year ago opened a new window to the Universe. The world learned about this on 11 February 2016 in a press conference that was organised by the US National Science Foundation, the main funding organisation, who fittingly recognised the large international collaboration – over a thousand engineers and scientists – involved in achieving this brilliant feat.

Upon the detection of a pertinent signal on 14 September 2015, the members of the collaboration performed a five-month long severe analysis before publicly reporting the result in February 2016. Simultaneously with the press conference, they released a peer-reviewed publication covering the measurement and its interpretation[1].

Fundamental discoveries accomplished by experiment do nowadays normally require that several institutions, often from different countries, join their capabilities. An announcement in a widely publicised press conference thus becomes an imperative. Like that by NSF, such announcements must be incontestable lest the credibility of science suffers.

None the less, overhasty announcements occur sporadically. The following story, about the *BICEP2* project claiming the "First Direct Evidence of Cosmic Inflation", lies back a couple of years; it is worth being told nevertheless, as it has a constructive ending.

The "First Direct Evidence of Cosmic Inflation" had been based on observations of the polarisation of the Cosmic Microwave Background (CMB) at a single frequency in a restricted part of the sky. Rather than working directly with *Planck*[2] scientists, the *BICEP2* collaboration used preliminary data that had been shown at a conference.

**Upholding the credibility of science.**

Three months after their announcement, the *BICEP2* project published a peer-reviewed paper, where a «Note added» mentioned "extensive discussions of our preprint in the cosmology community". In fact, doubt had been expressed about the significance of their result. Members of the Planck team, who had also looked into the problem, suggested a joint analysis[3]. Indeed, an article by both the *Planck* and the *BICEP2* collaborations then clarified that the significance of the *BICEP2* data was "too low to be interpreted as a detection of primordial B-modes"[4], *i.e.*, as evidence of cosmic inflation.

The two teams showed «Science Etiquette»: they put animosity aside, made use of the best data available and thus rectified a derailed breakthrough-announcement to the benefit of science's credibility! ■

[1] B. P. Abbott *et al.* (LIGO Scientific Collaboration and Virgo Collaboration) 2016, Observation of Gravitational Waves from a Binary Black Hole Merger, *Phys. Rev. Lett.* **116**, 061102 (2016) [DOI: 10.1103] (Published with open access on 11 February 2016). The detected signal stemmed from two massive black holes of 36 and 29 solar masses ($M_\odot$) that had merged into one black hole with 62 $M_\odot$ and radiated away the energy-equivalent of 3 $M_\odot$. [In the meantime a second merger has been observed on 26 December 2015.]

[2] *Planck* is a mission of the European Space Agency (ESA), launched in 2009, that has mapped the Cosmic Microwave Background (CMB) over the full sky at a large number of frequencies with unprecedented accuracy and precision. *Planck* also obtained a map of the CMB's polarisation (*cf.* http://www.esa.int/Our_Activities/Space_Science/Planck). Like the *LIGO* and *Virgo* Collaborations, the *Planck* Collaboration maintains a severe internal review system.

[3] Adam R *et al.* (*Planck* Collaboration) 2016, *Planck* intermediate results XXX. The angular power spectrum of polarized dust emission at intermediate and high Galactic latitudes, *Astron. Astrophys.* **586**, A133 [arXiv:1409.5738 (2014)] (Received by A&A 19 September 2014, accepted 1 December 2014, published February 2016)

[4] Ade PAR *et al.* (*BICEP2/Keck* and *Planck* Collaborations) 2015, Joint analysis of *BICEP2/Keck* and *Planck* data, *Phys. Rev. Lett.* **114**, 101301 (Published 9 March 2015)

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