

Report on

## The EPS-ESA-ESO-CERN Conference on Relativity, Matter and Cosmology

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This year the joint ESA-ESO-CERN symposium was held in conjunction with the European Physical Society, on the occasion of the Centennial of Einstein's *annus mirabilis* and the World Year of Physics. It took place on July 11–14 in Bern, where Einstein wrote his famous papers in 1905, and was part of a wide range of events to celebrate the centennial.

A highlight of these events was the 13th triennial General Conference of the European Physical Society (EPS13), with the title "Beyond Einstein – Physics for the 21st Century". It consisted of three parallel conferences, one of which was the EPS-ESA-ESO-CERN conference on "Relativity, Matter and Cosmology".

As is usual in these joint conferences, the objective was to provide a broad overview of current and future developments in the fields of fundamental physics, particle physics and cosmology. The fact that altogether some 600 participants attended the three conferences attests to the interest generated by the wide range of topics, as well as the wonderful setting in Einstein's Bern.

Some 80 talks were given at the conference on *Relativity, Matter and Cosmology*, and a substantial number of posters were presented. In a conference of this size and scope it is difficult to give a comprehensive summary, but an idea of the range of the science covered can be gleaned from this brief overview based largely on the invited plenary reviews.

A stimulating introductory talk entitled "100 Years of Relativity" was given by T. Damour. He summarised the remarkable success of the theory in a variety of stringent tests, provocatively going on to ask whether we should now just conclude that Einstein was 100% right and stop testing! Of course he then went on to describe ever more sophisticated planned tests, and concluded that new and exciting frontiers lay before us, including the great mysteries of dark matter and dark energy.

Gravity, including both theory and observations, was obviously a major topic at this conference. As H. Nicolai commented, reconciling general relativity and quantum theory into a consistent and predictive theory of quantum gravity is probably the greatest challenge facing theoretical physics in the 21st century. He described the successes and challenges of the two main approaches, superstring theory and canonical quantum gravity. C. Everitt described the dedicated space mission Gravity Probe B, designed to accurately test two aspects of Einstein's General Relativity: the effect of space curvature on a free gyroscope and the effect of relativistic frame dragging. It is currently collecting data and the first release will be in mid-2006. The direct detection of gravitational waves has been a dream for decades that may be realised in the near future. B. Schutz summarised the physics and possible astrophysical and cosmological sources of gravitational waves and the fundamental physics that we may learn from their detection, and K. Danzmann described current and future experiments and their prospects, in particular the planned LISA mission. Pulsars provide excellent natural astrophysical laboratories for tests of General Relativity, and D. Lorimer described results over the last years and the wonderful prospects with these remarkable systems, like the recently discovered double pulsar, that are increasingly being found.

Three speakers discussed the current state of observational and theoretical cosmology, and looked to the future challenges and horizons. J. Silk discussed the challenges of the cosmic microwave background, and stressed the potentially great importance of any hints of non-gaussianities, unexpected topologies or global anisotropies that may be found (either in the microwave background or the large-scale distribution of galaxies). G. Efstathiou gave a talk with the provocative title "Is There Cosmological Concordance?". He expressed confidence in the concordance of an impressive array of cosmological observations, including the microwave background, galaxy surveys and supernovae. He made the case for the existence of dark energy, suggesting that it may argue for anthropic reasons that we can observe it right now. Finally, D. Spergel gave an overview of

early universe physics and the achievements of WMAP so far. While he also highlighted the remarkable concordance of present observational results, he went on to emphasise the challenges: "Beyond Einstein: the physics we don't know and the physics we don't know how to calculate". He described the potential for rapid development in this field, with a whole host of new observational facilities becoming available over the next years.

Recent breakthroughs in neutrino physics, using neutrinos both from the sun and the laboratory, were summarised by G. Drexlin, including the now conclusive evidence for neutrino oscillations and hence for nonzero neutrino masses. He mentioned several open questions, and the new round of experiments proposed to answer them. E. Fiorini summarised ongoing work on neutrinoless double beta decay, and prospects for the detection of weakly interacting massive particles, a possible candidate for dark matter, based on seasonal variations due to the earth's motion around the sun. J. Bluemer gave a review of the study of cosmic rays since their discovery over 90 years ago, and the current and planned experiments to understand the astrophysical sources and the extraordinary energies involved.

The fundamental problem of the origin of mass was addressed by G. Ross. He described how explorations of this problem have led to extensions of the Standard Model which unify all the fundamental interactions including gravity; a new energy frontier may exist which can affect early universe physics and will be probed by CERN's Large Hadron Collider (LHC). A new state of matter, the Quark-Gluon Plasma, was the subject of J. Stachel's presentation. She summarised the recent experimental support for the existence of this state, which may have existed in the early universe until 10 microseconds after the Big Bang, and the potential of the LHC in studying it. F. Iachello gave an overview of symmetries and supersymmetries in nuclei, and placed them in the broader context of complex systems in general. They, too, will be major targets for the LHC. The huge scientific potential of the LHC was described by J. Engelen, in particular the possibility of detecting the Higgs boson; he summarised the status

of the project, which should become available for experiments in 2007. W. Gelletley spoke on the broad perspectives, challenges and opportunities in nuclear physics, including the upcoming new experimental facilities. A different kind of huge project, the first experimental fusion reactor (ITER), was described as part of F. Wagner's comprehensive overview of the current state of plasma physics.

Possible variations in the fundamental "constants" of physics also generated a lot of interest. Recent VLT data have contradicted earlier claims of the fine structure constant having been smaller in the early universe than today. M. Murphy summarised this controversy and described ongoing efforts to resolve it. E. Reinhold reported on recent progress

in trying to detect a change in the proton-to-electron mass ratio, also using VLT data.

The importance of dark energy to modern physics was emphasised by several speakers. Its existence was first established through observations of distant type Ia supernovae and the talks by R. Pain and J. Sollerman demonstrated that searching for these transient events remains a vigorous industry. They outlined the two main projects in this field: SNLS and ESSENCE. Understanding the nature of dark energy was the subject of several theoretical talks, involving D-branes (P. Gusin), Casimir Energy (R. Garattini), quantum gravity (A. Ernest and C. Bryja) and Modified Chaplygin Gas (U. Debnath).

Finally, J. Liske outlined plans to use OWL, the VLT's successor, for the Cosmic Dynamics Experiment (CODEX). The aim is to supplement our knowledge of the universe's *geometry* (derived from the microwave background and supernovae) with an unprecedented measurement of its *dynamics* and hence to provide us with a fundamental consistency check of General Relativity.

The sampling above gives some idea of the wide range of physics and cosmology that was covered at the conference. The full proceedings of the conference will become available; they will be published by the ESA Publications Division as ESA Special Publication SP-605.

## ESO Public Activities in July 2005

### Ed Janssen (ESO)

The month of July is, in many parts of Europe, considered to be a relatively "quiet time" of the year with many millions of people away on summer vacation. Not so for ESO's Public Affairs Department. The month began with a series of press activities around the Deep Impact event and included several press conferences at the ESO Headquarters (mostly at odd hours!), video press conferences with Paranal, La Silla and ESTEC in the Netherlands, live TV transmissions from ESO Garching as well as from Paranal, etc.

In parallel, from July 4–8 the Joint European and National Astronomy Meeting (JENAM) took place at the Amphithéâtres de l'Europe in Liège, Belgium. The meeting, organised this year by the Astronomy Department of the Liège University, had the theme "Distant Worlds". It was attended by over 200 astronomers. The meeting

also enjoyed a good media attendance, probably also due to the Deep Impact Mission. As at previous JENAM meetings, ESO maintained an information stand in the lobby area and participated in the press conference.

Several ESO staff members gave talks, including the ESO DG, Françoise Delplancke, Henri Boffin, Maximilian Kraus and Marc Sarazin. Furthermore, a Round Table was held to discuss financing, organisation and industrial aspects of large European astronomical projects. It was chaired by Lodewijk Woltjer, former ESO director general. From ESO Roberto Gilmozzi participated as a speaker.

On July 7, ESO participated in a major Press Event on the Future of Astronomy Research Infrastructures, organised by the European Commission and hosted by JIVE, in Dwingeloo, the Netherlands. The event was attended by EC Research Commissioner Janez Potocnik and Maria van der Hoeven, Dutch Minister for

Prof. Jean Surdej, one of the local organisers, being interviewed by RTL television at the JENAM conference.



Photo: E. Janssen, ESO



Photo: JIVE

EU Commissioner Dr. Janez Potocnik and Mrs. Maria van der Hoeven, Dutch Minister for Education, Culture and Science answer questions from the media representatives at the press meeting in Dwingeloo.