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Joint Discussion 1
Particle acceleration – from solar system to AGN

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Abstract. The scene is set for IAU JD01 on Cosmic Particle Acceleration: from Solar System to AGNs

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Preface

The first suggestion of this meeting came from Marian Karlický and others at the June 2004 meeting of CESRA at Sabhal Mhor Ostaig (Gaelic College), Isle of Skye. Aptly, this is only about 100 km from the Observatory on Ben Nevis, where C.T.R. Wilson carried out his pioneering cosmic ray (CR) work and whose Brocken Spectre inspired Wilson's invention (<www.gla.ac.uk/adulteducation/Personnel/alec/wilson/index.html>) of the cloud chamber.

The meeting was also very timely in view of the fact that, since the last IAU meeting dedicated to accelerated particles (IAU Colloquium No. 142 in 1993, Maryland – *Particle Acceleration Phenomena in Astrophysical Plasmas*), as well as theoretical progress, there have been major observational advances in all high-energy wavebands. The field of very-high-energy γ-ray astronomy has finally achieved maturity, with confirmed detections of both point and diffuse sources of galactic and extra-galactic origin by experiments such as VERITAS, CANGAROO, HEGRA, CAT and HESS, using imaging Cerenkov telescopes. All of these high-energy advances have been further enhanced by coordinated multi-wavelength observations using both established and new facilities, especially radio. These and other facilities have expanded our knowledge of particle acceleration on all cosmic scales, including:

- Planetary and interplanetary particles – *CLUSTER, Ulysses, Cassini, WIND*
- Solar flare particles – *Yohkoh, Compton Observatory, RHESSI, WAVE, Granat, Koronas*
- Stellar fast particles in colliding hot star winds and cool star flares - *Chandra, XMM, Compton GRO*
- Pulsars, plerions, shell-type SNRs and GRBs – CANGAROO, HESS, *Integral, RXTE, Beppo-SAX*
- Extra galactic jets and AGNs – *Chandra, XMM, Integral, Compton GRO*, VERITAS, HEGRA, HESS
- Ultra-high-energy cosmic rays – Auger, Fly's eye, AGASA

While reports on these major observational developments are included, the main thrust of this meeting was toward improving our knowledge and understanding of the physical processes involved – especially plasma/particle kinetic and wave phenomena and intense beam electrodynamics, as opposed to MHD. Mean free paths of cosmic energetic particles are generally very large compared to length scales of primary energy conversion (current sheet thickness, shock scale, mirroring length, etc.). Given that fast particles constitute much of the total energy, it is clear that particle kinetics is a vital aspect that must

be integrated with MHD approaches in order to achieve credible theories of the overall energy release and particle acceleration process in high-energy sources.

Particle acceleration is a ubiquitous phenomenon on all cosmic scales and one of the remaining great enigmas of astrophysics. In the big picture, within the realms of 'visible' matter, energetic particles (cosmic rays or CRs) rank with galaxy rotation and magnetic fields in the league table of cosmic energy densities, falling behind only the mean densities of stellar thermal and gravitational energies. In many, if not all, energetic sources , from solar flares to GRBs, the total fast particle numbers and energy can be a large fraction of the total system content. This poses efficiency problems of energy and particle supply in addition to those of achieving high energies of individual particles, again found on all scales from terrestrial lightning through aurorae and solar/stellar flares to supernovae (SN), pulsars, GRBs and AGNs. Even in our own daily lives, accelerated cosmic particles play roles ranging over the disruption of power and data transmission by flares and CMEs, the solar cycle linked influence of CRs on cloud formation and climate, and the potentially lethal effect of CRs from a nearby SN.

Thus, the observed properties of, and acceleration theory for, energetic particles lie at the heart of a number of key problems on all cosmic scales, as well as being important in both hot fusion and cool lab plasmas. Despite this, particle acceleration processes remain among the greatest unsolved problems of plasma (astro)physics. These facts were the original driver in our proposal of this Joint Discussion. The aim of the meeting was thus to bring together experts from across the whole range of IAU disciplines concerned with accelerated particles and from all pertinent domains of observed energy, diagnostic modelling, and theory, to share and enhance understanding of all acceleration mechanisms and their relevance in each cosmic regime. As the following pages show, this goal was amply achieved via the excellent invited and contributed talks, and the posters, which ranged both observationally and theoretically from impulsive solar electrons above 10 keV to ultra-relativistic radiation dominated plasmas.

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We are grateful to the IAU for supporting our proposal and to all the participants who made it a great success. We look forward to further discussions of this exciting field at a session in the Rio GA 2009. In the same spirit as that in which cosmologists have recently re-discovered issues of star formation under the name of *cosmic re-ionization*, we should very possibly hold that session with a re-badging of our field as *cosmic re-acceleration*. Particles of the early universe declined rapidly in energy as the Big Bang proceeded, but some of them are now being returned to very high energies by plasma electric fields, having their ultimate origins in the same gravity driven formation of hot condensed plasmas (stars and galaxies) as is responsible for radiative cosmic re-ionization. May progress and funding of acceleration studies itself accelerate as quickly as possible.

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John C. Brown, co-chair
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