

Preface

Branches of astronomy are often defined by observational band or technique, such as "optical" or "radio" or "high-energy" astronomy. Such an experimental approach to astrophysical problems has been supplemented in recent years by "multi-wavelength" views, aimed at a concerted effort to understand particular astrophysical processes which incur phenomena *across* such astronomical branches. Our astrophysical challenge is the physics around formation of fresh nuclei in the universe. This occurs inside stars in either static or explosive burning, through nuclear fusion reactions, but also in interstellar space via high-energy particle interactions. Theories for cosmic nucleosynthesis have been developed following the pioneering insights by Cameron and Burbidge, Burbidge, Fowler, & Hoyle in 1957. Observations of radioactive isotopes through gamma-rays ensued from pioneering gamma-ray experiments following the Apollo program of the 70ies and balloon experiments (e.g. Haymes et al. 1964), but also the emergence of isotopic analyses of stardust in the laboratory after Ca-Al-rich inclusions of meteorites had been recognized as carriers of presolar signatures by Clayton et al. (1973). The most direct bridge between theories of cosmic nucleosynthesis and observation of its products is possible with trace isotopes whose gamma-ray signals are detectable with current detector technology. As the theme of this Volume, we therefore combine a multi-discipline view of "Astronomy with Radioactivities" with a dedicated look at the frontier of gamma-ray telescopes.

The contributions appearing in these proceedings arose from a workshop at the Bavarian Conference Center of Seon in Germany in May 2003. Researchers from traditional observational fields (in gamma-ray, X-ray, optical, infrared, and radio astronomy), as well as experts on cosmic-ray physics, meteoritics, stellar evolution, nova and supernova models, galactic structure and chemical evolution, came together with gamma-ray experiment developers for inter-disciplinary discussions around the common themes of *learning about the formation of cosmic nuclei* and *advancing the observational methods for MeV gamma-rays*. The 5-day workshop featured 62 talks and several posters, enriched by many discussions during lecture breaks and an excursion to the island and castle of Herrenchiemsee. All participants enjoyed the stimulating environment of the retreat with its beautiful panorama of the Bavarian Alps - and most agreed to pay their dues with contributions to

these proceedings. More information on this workshop series can be found at

www.mpe.mpg.de/gamma/science/lines/workshops/radioactivity.htm

Oral presentations at the workshop began with an overview and update on theories and models for cosmic sites of nucleosynthesis during hydrostatic evolution of massive stars, supernova and nova explosions, and their amazing trajectories ending up even in terrestrial materials. Then the recently-launched INTEGRAL nuclear-astrophysics observatory was presented next to the new nanoSIMS instruments for laboratory studies of presolar grains. Detailed discussions of recent developments to understand the impacts of stellar rotation and asymmetric explosions followed. Then the fate of the new nuclei from explosive release into interstellar space was discussed. The various observational aspects of young supernova remnants in recent high-resolution X-ray spectrometers such as XMM-Newton and gamma-ray spectrometers such as RHESSI and SPI aboard INTEGRAL, but also optical, UV, and IR light curves, are very complex and not easy to disentangle in terms of nucleosynthesis. Observations of specific objects were presented, and the inner Galaxy diffuse gamma-ray line emission was discussed. The discovery report of Galactic ^{60}Fe with RHESSI was a highlight of this session. The connections to isotopic signatures in presolar dust, stellar atmospheres of metal-poor halo stars, cosmic rays and in solar-flare results were drawn and explored by several speakers. A special session was dedicated to the ^{60}Fe of extraterrestrial origin found recently in Pacific oceanfloor samples, and its implications for nearby nucleosynthesis events.

Introducing the second part of the workshop, the open issues in the study of cosmic nucleosynthesis were presented in the form of challenges for the next-generation gamma-ray telescopes. Lessons from recent telescope projects and missions were summarized. Then different experimental approaches such as coded masks, rotating modulating collimators, and Compton telescopes were presented conceptually, and the prospect of measuring the polarization of gamma-rays was discussed. The prominent role of simulation software in development and optimization of detector and experiment platform designs, in mission configurations, and in assessments of the characteristics of large intrinsic background was outlined. Finally, an impressively-large number of experimental projects of new gamma-ray telescope techniques demonstrated their status,

achievements, and problem areas, spanning the range from laboratory tests of new detector types to balloon campaigns of prototype telescopes and preparations for upcoming satellite missions. It was clear that a diversity of ideas are being pursued, many of them promising, but all too costly for any one of the experimental groups. The prospects of the space agencies, as also presented at the workshop, however made clear that the experimenters' community will have to compromise and pool resources, in order to achieve a feasible MeV telescope mission before this special experimental expertise is further diversified and might fade away.

The remarkably-reduced sensitivity of astronomical surveys at MeV energies, in comparison to adjacent energy bands of hard X-rays and GeV gamma-rays, reflects the major experimental challenge of this photon-energy band. Our workshop highlighted once more the unique role of this band for nuclear astrophysics. We hope that eventually this "*sensitivity gap*" can be filled through a new effort to establish a gamma-ray experiment, for the direct study of radioactive isotopes from nucleosynthesis, but also of relativistically accelerated particles in active galaxies and near compact stars.

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