Los Alamos National Laboratory
Los Alamos Astrophysics

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The following review presents a set of highlights of the astrophysics work at Los Alamos National Laboratory covering the work from October 2002 through September 2003.

1. FOREWORD

Astrophysics at Los Alamos National Laboratory (LANL) covers a range of disciplines, groups, and divisions. As astrophysics is not an official ''mission'' of the laboratory, very few staff-scientists work full-time on astrophysics. However, LANL boasts over 50 scientists spending $>15\%$ of their time working on astrophysics. Many more scientists had dissertation topics in astrophysics and are now working on projects related to national security. Astrophysicists are trained in many of the skill requirements for these projects and make ideal scientists for LANL ''mission'' projects. Astrophysics also serves LANL by highlighting both instrument and computational advances at the lab. For both these reasons, astrophysics plays a continued and vibrant role at LANL.

2. SCIENTIFIC ACCOMPLISHMENTS SEPT. 2002 - SEPT. 2003

2.1 Computational Astrophysics

The bulk of the theoretical work at LANL involves large-scale computation and the development of theoretical tools necessary for these calculations (such as material equations of state). Most of these calculations utilize a variey of stellar evolution and multi-dimensional parallel radiation hydrodynamics codes both brought to the lab by incoming scientists or developed at LANL and modified to attack astrophysics problems: e.g. UCSC's Kepler code, LSU's uniform mesh hydrodynamics, LANL/SAIC RAGE adaptive mesh refinement, and the LANL/UA/UCSC 2D/3D SNSPH smooth particle hydrodynamics.

Scientists at LANL, collaborating with astrophysicists across the world, are using these codes to model a variety of astrophysical phenomena from asteroid impacts, planet formation and spectra of planets to stellar evolution, x-ray bursts, novae, supernovae, gamma-ray bursts, white dwarf cooling, and the merger of compact binaries to the galactic center, black hole accretion disks, to primordial dwarf galaxy formation, globular cluster formation and cosmology.

LANL also does extensive work studying the detailed physics necessary for these calculations from hydrogen equations of state, to photon (and neutrino) opacities and equations of state for planets, white dwarfs, and neutron stars. LANL astrophysicists are also developing new computer tools from state-of-the-art Beowulf clusters to distributed disk arrays to store, and allow quick access to, data (also applicable for the National Virtual Observatory).

Research Highlights This Year

Stellar Collapse: Most of the publications this year have concentrated on massive stars, their evolution, collapse and subsequent explosions. LANL scientists have modernized the Kepler stellar evolution code and have studied the effects of new nuclear burning rates on the evolution of massive stars. Coupling these results with collapse calculations using 2-dimensional and 3-dimensional SNSPH codes, LANL scientists have been able to better outline the fates of massive stars - from supernova, to hypernova, to gamma-ray burst. Collapse calculations have also allowed LANL scientists to better constrain the gravitational waves from the final stages of these stars' lives.

In supernovae, LANL also simulated the first 3-dimensional explosions from stellar collapse, calculating the mixing of the ejecta produced by the explosive nucleosynthesis. LANL scientists worked on the dust formation in these explosions. The physics in the compact remnants of these explosions have also been studied, with particular emphasis on the possibilities of quark condensation in the newly formed neutron stars. On gamma-ray bursts, LANL scientists studied the neutrino driven mechanism behind the collapsar gamma-ray burst engine. These theoretical studies complement much of the experimental astrophysics research at LANL.

2.2 Experimentation and Observations

LANL is involved in several major instrumentation projects with team members froma round the world. These instruments include the Sloan Digital Sky Survey to rapid slewing telescopes such as ROTSE and RAPTOR to high energy satellites and ground based observatories: XMM, HETE, Swift, EGRET, and Milagro. LANL scientists are active in both designing hardware and software for these observatories and in directing the science in these projects. LANL is one of the world leaders in transient observations, developing both rapidly-slewing telescopes and software and computational storage to manage rapidly variable data.

Research Highlights This Year

Gamma-Ray Bursts and High Energy Transients: With their background in transient telescopes and high energy telescopes, LANL scientists are ideally poised to do a number of studies of Gamma-Ray Bursts. From the first survey results of HETE to the individual studies of GRBs in X-rays (XMM) and in the very high energy regimes using EGRET and Milagrito, LANL scientists have continued to push forward our understanding of these objects.

LANL scientists have also studied X-ray transients for hints into gamma-ray burst explosion characteristics. LANL scienctists have assembled archival data from Ariel-5, HEAO 1 (A-1 and A-2), WATCH, ROSAT, and Einstein to produce a global fluence-frequency relationship for fast X-ray transients. The sources of fast X-ray transients are undoubtedly heterogeneous, representing several physical

phenomena, but the two major contributions come from gamma-ray bursts and stellar flares.

X-ray Studies: As part of the XMM team, LANL scientists have been part of a number of X-ray observations beyond gamma-ray bursts. They have studied the X-ray emission from Seyfert galaxies, difuse X-ray emission from M31, and discovered the first X-ray binaries in M31. LANL scientists have used the time-dependent features of XMM to studied the pulsed X-ray emisions from pulsar J0538+2817.

The many scientists at LANL have observing programs well beyond those highlighted here, including MACHO observations, SDSS white dwarf observations, and studies of variable stars.

3. CONFERENCES SUPPORTED BY LANL

LANL supports a number of astrophysics workshops and meetings in New Mexico. Meetings and workshops supported by LANL from September 2002 to September 2003 were:

- *''SF03 Cosmology Workshop''*, July 7-25, Santa Fe, organizer S. Habib (T-8, LANL) http://t8web.lanl.gov/people/salman/sf03/.
- *''Physics and Astrophysics of Neutron Stars''*, July 28 - August 1, Santa Fe, organizers R. Epstein (NIS-2, LANL), C. Fryer (T-6, LANL), S. Reddy (T-16, LANL) http://neutron-stars.lanl.gov/.
- *''30 Years of Discovery: GRB symposium''*, September 8-12, Santa Fe, organizer E. Fenimore (NIS-2, LANL) http://grb2003.lanl.gov/.

PUBLICATIONS

The publication list includes all refereed papers published between September 2002 and September 2003 by the LANL Staff or Postdocs.

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Hungerford, A. L., Fryer, C. L., Warren, M. S., 2003, ''Gamma-Ray Lines from Asymmetric Supernovae,'' ApJ, 594, 390-403.

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Mason, K. O. *et al.*, 2003, ''The X-Ray Spectrum of the Seyfert I Galaxy Markarian 766: Dusty Warm Absorber or Relativistic Emission Lines?,'' ApJ, 582, 95-104.

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