SLAC National Accelerator Laboratory

11th International Conference on High-Energy Density Laboratory Astrophysics

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Event Summary of the 11th HEDLA conference held at SLAC National Accelerator Laboratory, Menlo Park, CA from May 16th to 20th, 2016.

The 11th International Conference on High Energy Density Laboratory Astrophysics was held at the SLAC National Accelerator Laboratory in Menlo Park, California on May 16-20, 2016.

This event marked the 20th anniversary of the HEDLA conference series and provided a great opportunity to discuss exciting recent work and future prospects in laboratory astrophysics. During the past decade, research teams around the world have developed astrophysics-relevant research utilizing high energy-density science facilities such as intense lasers, x-ray lasers and z-pinches. Research is underway in many areas, such as compressible hydrodynamic mixing, shock phenomena, magnetic reconnection, turbulence, jets, dynamos, heat conduction, radiative transport, complex opacities, equations of state, warm dense matter, relativistic plasmas, pair plasmas, and QED.

The conference was co-organized by the SLAC National Accelerator Laboratories, Stanford University, Lawrence Livermore National Laboratory, and the University of California, Berkeley. The meeting was a great success, with a record number of attendees, which exceeded 170 scientists, including 32 invited speakers, 32 students, and postdoctoral scientists from America, Asia and Europe. The meeting focused on five main topics:

1) Dense Plasmas (EOS, warm dense matter, planetary interiors,…)

2) Fluid and Collisional Plasmas (jets, turbulence, dynamos, instabilities,…)
3) Transport and Atomic Processes (heat conduction, anomalous resistivity, diffusion, radiative transport, opacity, line shapes, photoionization,…)
4) Collisionless Plasmas and Particle Acceleration (shocks, magnetic reconnection,…)
5) New Frontiers (QED, pair plasmas, nuclear astrophysics, new experimental facilities, computing,…)

Both oral and poster sessions led to important discussions between plasma physicists and astrophysics, theorists and experimentalists, with the goal of identifying the most exciting research opportunities in HED laboratory astrophysics and understanding how the different communities can work together and learn from each other in the pursuit of these goals.

Two conference proceedings will result from this conference:

1) 16 selected invited papers for Physics of Plasmas, special topics issue, guest editors S. H. Glenzer and M. Mauel

2) 52 contributed papers in the journal of High Energy Density Physics, guest editors G. Gregori and S. H. Glenzer

Conference highlights:

Dense Plasmas

D. Stevenson (Caltech) – Inside Planets: Dense Plasmas and the Thermodynamics of Mixing
Thermodynamics of mixing to the atomic level is king. This affects the energy budget of the planet, its observable part, and influences our interpretation of how the planet is formed. Whether or not Jupiter has a solid core affects the way we think about how planets form. Jupiter is particularly important because it is the biggest one who affected everybody else. Conductivity of the core is important as it affects the geodynamo processes. The EOS of different materials is important: H-He, H2 – H2O, H/O/C, Mg/Si/O/Fe.

J. Fortney (UCSC) – Modeling Planetary Interiors in the Exoplanet Era
Radius versus Me plots show many planets above the iron, rock and water EOS lines due to H contents.
It is important to do an EOS measurement with H2He mixtures!

Stephanie Brygoo (CEA) – Observation of H/He demixing under deep Jovian planetary conditions
For the evolution, important are: Magnitude of He, EOS, atmospheric boundary conditions
De-mixing will result in increase in reflectivity – otherwise it is really hard to make He reflective (30000 K at 200 GPa while H reflects at 5000K at 200 GPa). Sign of de-mixing observed by change in reflectivity – 4 or 5 shots at the highest pressure show the effect.

Fluid and Collisional Plasmas

P. Tzeferacos (Chicago) and G. Gregori (Oxford) - Turbulent Dynamo Amplification of Magnetic fields in Laser-Produced Plasmas
Recent experiments at the Omega laser and corresponding MHD simulations indicate amplification of magnetic fields by the interaction of counter-streaming turbulent laser-driven plasmas. Small-scale turbulent dynamo is believed to be the responsible mechanism.

C.K. Li (MIT) – Scaled laboratory experiments explain the kink behavior of the Crab Nebula jet
Recent experiments at the Omega laser show the formation of a plasma jet in the oblique collision of two laser-ablation plasmas. The jet is observed to be unstable to kink in both experiments and simulations.

I. Zhuraveleva (Stanford) - Clusters of Galaxies as Laboratories for Low-density Plasma

Recent satellite measurements show that the turbulent speed of the plasma at the center of the Perseus galaxy cluster is only ~150 km/s.

Transport and Atomic Processes

J. Bailey (Sandia) - Measuring the radiative properties of astrophysical matter using the Z x-ray source
Recent opacity measurements are off for Fe, not for Ni. Call for a repeat of the experiment in a different facility by a different group.

Y. Ping (LLNL) – Thermal conductivity measurements in warm dense matter
Conductivity calculations in earth interior conditions show 2-3x higher values than used in earth models.

Collisionless Plasmas and Particle Acceleration

A. Spitkovsky – Open questions in astrophysical shocks and reconnection
Particle injection in shocks is a critical open question that laboratory experiments can help solve. Simulations indicate that particles get injected at special moments in time during the shock propagation and that the angle of incidence matters.

C. Huntington – Laboratory experiments investigating magnetic field production via the Weibel instability in interpenetrating plasma flows
Recent experiments at the Omega laser facility and corresponding PIC simulations have demonstrated the amplification of magnetic fields by the Weibel or current-filamentation instability. Experiments are now being conducted at NIF to observe the formation of collisionless shock mediated by this instability.

D. Schaeffer – Generation of Magnetized Collisionless Shocks by a Laser-Driven Magnetic Piston
Recent experiments at LAPD have characterized the formation and the structure of magnetized collisionless shocks with Alfvenic Mach number ~ 2.

N. Loureiro – Magnetic Reconnection: Recent Advances and Outlook for Laboratory Astrophysics
The formation and stability of current sheets is a critical aspect to understand magnetic reconnection. Recent theoretical work has determined the minimum Lundquist number for the generation of plasmoids. Laboratory experiments can be important in validating these theoretical models and in understanding the detailed physics of energy dissipation at the reconnection region.

S. Totorica – Nonthermal Electron Energization from Magnetic Reconnection in Laser-Driven Plasmas
3D PIC simulations for current Omega laser conditions show the possibility of studying non-thermal particle acceleration from magnetic reconnection. The results indicated that acceleration at x-points is dominant and leads to high-energy tails with ~50x the thermal electron energy.

New Frontiers

J. Kirk – Strong waves in astrophysics and the laboratory
QED processes relevant for astrophysical models can also occur in laboratory configuration involving ultrahigh intensity lasers. In the presence of two or more ultraintense non-plane waves the dynamics of electrons become highly complex leading to dissipation via non-linear Compton scattering but also through electron-positron production. Radiation reaction, which plays a critical role in the coupling process could be studied in future experiments.

T. Grismayer – Electromagnetic QED cascades: From the laboratory to astrophysics
QED physics has been implemented in multi-dimensional PIC simulations and used to model QED cascades from the interaction of two high-intensity laser pulses. The results were compared with recent theoretical models showing important differences.

H. Chen – Making relativistic pair plasma jets for laboratory astrophysics on the National Ignition Facility
Recent experimental results on the production of electron-positron jets from the irradiation of Au foils with high-power lasers were presented. It has been found that the positron yield scales with the square of the laser energy. Simulations show that for 10 kJ class laser systems pair yields can approach 10^{14} and allow the study of the microphysics of relativistic pair shocks in the laboratory.

Conference Banquet Talks

R. Byer (Stanford) gave the banquet invited talk on the LIGO discovery of gravitational waves.

B. Remington (LLNL) discussed the history of the HEDLA meeting and presented a summary of the previous conferences.

The group photo shows the attendees of the 2016 High Energy Density Laboratory Astrophysics Conference held at SLAC National Accelerator Laboratory, Menlo Park, CA, May16-20, 2016. A high-resolution copy of the picture can also be found online at
http://media.slac.stanford.edu/multimedia_comms/temp/smith/2016_0518_HEDLA_group_photo/2016_0517_HEDLA_group_photo_7689_full_res.jpg