# What is laboratory astrophysics, and what does it have to do with the rest of science …

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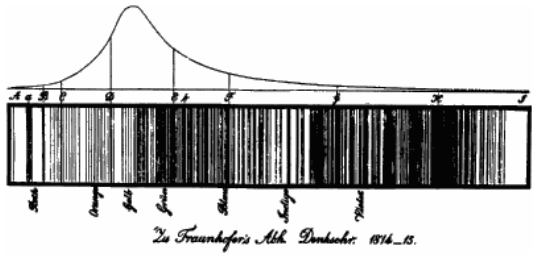
Presented to the Plasma Science Committee

April 13, 2007

**1. What is laboratory astrophysics? What defines the field**, and what are examples of research (especially current projects) that fall within its purview? We may be just a committee of plasma scientists, but we're trying to think more broadly.



- Joseph Fraunhofer (1817): accurate description of 'dark solar lines'
- J.F.W. Hershel: absorption in cool terrestrial atmospheric gas or in sun's atmosphere
- G.R. Kirchhoff/R.W.E. Bunsen: lines due to absorption by cool gases, based on laboratory data

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

- ***'One important object of this original spectroscopic investigation of the light of the stars and other celestial bodies, namely to discover whether the same chemical elements as those of our earth are present throughout the universe, was most satisfactorily settled in the affirmative; a common chemistry, it was shown, exists throughout the universe.'***

  **-Sir William Huggins**

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- The classical issues: equations of state, nuclear cross sections, atomic processes, …
- Origin(s) of cosmic magnetic fields: *dynamo experiments*
- Plasma energization/reconnection/particle acceleration: *lab plasmas*
- Spatial organization of magnetic plasma structures: *lab plasmas*
- Plasma and MHD turbulence, effective transport properties: *lab plasmas*
- Accretion in protoplanetary systems/close binaries/…: *Taylor-Couette*
- Jet acceleration, confinement, collimation, and stability: *lab plasmas*
- HEDP/relativistic plasmas: NIF/OMEGA/Z/…
- …

## 2. How does laboratory astrophysics relate to other fields of science?

- **Atomic physics:** Much of modern laboratory atomic physics has emerged from laboratory studies motivated by astrophysical 'needs' - ranging from radiation transfer/transport to (plasma) diagnostics
- **Computational physics:** Laboratory verification & validation (V&V) is at the heart of modern computational science
- **Condensed matter/HED physics:** Material properties at extraordinary conditions (e.g., degenerate matter, …) probe our understanding of theoretical condensed matter physics (e.g., RHIC, OMEGA/NIF/Z)
- **High energy physics:** Questions about the nature of dark energy and dark matter, as well as about stellar evolution, directly link to HEP experiments probing the 'standard model', as well as to experiments probing neutrino properties
- **Nuclear physics:** Both primordial and stellar nucleosynthesis (in 'steady state' or in transients) relate to questions of nuclear structure, especially far off the 'valley of stability' (e.g., ATLAS, [RIA])
- **Plasma physics and fluid dynamics:** Virtually all lab astrophysics problems/questions find a counterpart in laboratory/terrestrial plasma physics and hydrodynamics

# Questions & discussion …

Dear Cary, Bob, Jim, and Kate:

We look forward to engaging you all in a panel discussion at the April13, 2007, meeting of the Plasma Science Committee. Since the time you accepted our invitations, we have further organized our thoughts. As you might see from the attached agenda, we are setting aside about two hours on Friday afternoon for this discussion. During the first phase, we would like each of you to present about 15 minutes of prepared remarks addressing the following two questions.

- 1. What is laboratory astrophysics? What defines the field and what are examples of research (especially current projects) that fall within its purview? We may be just a committee of plasma scientists, but we're trying to think more broadly.
- 2. How does laboratory astrophysics relate to other fields of science?

During the second phase, we will hold a more general discussion with the full committee. We will start from the issues that you raise and seek to identify the most pressing issues for the future of the field. The hoped-for outcome would be clarity about role the NRC could play in facilitating progress in the field. I should note that in addition to this panel discussion, Kate Kirby and several others have undertaken the task of drafting a position paper on the topic. The combination of that effort and this panel discussion might be enough to get some good momentum. If you would like to send us an e-mail copy of your remarks in advance of the meetings so that we may provide the committee with hard copies,please send us your PPT or PDF file by Tuesday, April 10, 2007.

Thanks again, and best regards,

Tim Meyer

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