

Measuring huge magnetic fields in the laboratory

Using a new technique, super-strong magnetic fields have been shown to exist in plasmas created with high intensity laser pulses – a development which may allow the study of exotic astrophysical phenomena in the laboratory.

Huge magnetic fields have been measured for first time in the laboratory with the help of the ultra-high intensity laser system at the Rutherford Appleton Laboratory near Oxford in the UK (VULCAN). Researchers from the plasma physics group of the Imperial College of Science, Technology, and Medicine (University of London) and the Rutherford Appleton Laboratory have measured magnetic fields of the order of 400 MegaGauss when the ultra intense picosecond-duration laser pulse interacts with a dense plasma [1,2]. These observations were performed by measuring the polarization of high frequency light emitted during the experiment. Recent measurements presented at the APS/DPP conference suggest that the peak magnetic field approaches 1 GigaGauss in these interactions and that spatially and temporally resolved measurements of these fields are possible. These fields are about one billion times greater than the magnetic field at the earth's surface and are two orders of magnitude greater than any previous fields produced in a laboratory on earth. Such magnetic fields begin to approach those required to generate Landau quantization of electron motion in hydrogen (i.e., the shape of the electronic orbital around the nucleus becomes significantly distorted by the presence of the field). Due to technological advances peak laser intensities are likely to increase still further and consequently even higher magnetic fields may soon be possible. Under such conditions the equation of state and the radiative spectral opacities in the plasma may be significantly affected. Consequently, astrophysical models developed for such extreme conditions (such as those in the atmospheres of neutron stars and white dwarfs) may soon become testable in the laboratory.

1) M. Tatarakis *et al.*, *Nature* **398**, 489 (2002).

2) M. Tatarakis *et al.*, *Phys. Plasmas* **9**, 2244 (2002).



The Crab nebula – which is the remnant of a supernova explosion observed in 1054 AD by Chinese and Japanese astronomers. In the center of the nebula a neutron star rotates with a frequency of 30 times per second (pulsar). The blue color shows the region in which electrons spin in the huge magnetic field. In the near future, it may be possible to reproduce these conditions in the laboratory.