Recent Advances in Fast Ignition Studies

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Rapid progress has been made in the past four years in testing the concept of fast ignition of fusion targets. Simultaneous compression to high densities and significant heating by fast electrons has been demonstrated in pioneering experiments by a British-Japanese team using the Vulcan and GEKKO XII laser systems [1]-[4]. PW laser to thermal energy conversion efficiencies of 20% were inferred from the measurements. The results have been so encouraging that the construction of even more powerful laser facilities has already begun. The University of Rochester, for example, has started the construction of the OMEGA Enhanced Performance upgrade to the existing 40kJ nanosecond pulse duration drive laser. This system is expected deliver 4kJ of short pulse energy when construction is completed in 2007. The FIREX project in Japan has also been approved - and is designed to deliver 10kJ of short pulse energy at around the same time. Both systems may get close to equivalent conditions to energy breakeven by using deuterium-deuterium fusion reactions (rather than deuterium-tritium reactions which have a higher fusion cross section, but increased handling problems due to the radioactive properties of tritium).

In this lecture, I will report on the most recent progress in understanding energy transport in PW-laser plasma interactions. These include control of the fast electron beam divergence in cone-guided geometries and a new interpretation of integrated cone-guided experiments on Vulcan. I will also describe novel measurements of the ion temperature gradient in PW-laser plasma interactions using neutron spectroscopy that have allowed the energy transfer question in cone-guided implosions to be understood for the first time. The results suggest that there are no physics barriers preventing fast ignition becoming a serious candidate for fusion energy generation.

[1] P.A.Norreys *et al., Physics of Plasmas* **7**, 3721 (2000)
[2] R.Kodama *et al., Nature* **412** 798-802 (2001)
[3] R.Kodama *et al., Nature* **418**, 933 (2002)
[4] P.A.Norreys *et al., Physics of Plasmas* **11**, 2746 (2004)