Seminar by B. Grant Logan to CEA-ENS-CACHAN
Title: "Inertial confinement fusion and high magnetic fields"
12:00 to 13:00 Thursday, 21 May, 2015

Abstract:

Two major laser fusion facilities- the US National Ignition Facility, operating since 2009, and the Laser Megajoule (LMJ) now beginning operation in France, and two more megajoule-class lasers planned in China and in Russia, provide an unprecedented opportunity to study the self-heating of fusion plasmas by alpha particles (ignition) in the relative near term. Interest in inertial confinement fusion (ICF) targets with applied axial magnetic fields has rekindled since Omega (LLE, Rochester, NY) direct drive implosions of spherical plastic capsules filled with deuterium gas and pre-magnetized to 8 T showed higher ion temperatures and neutron yields (Chang, et.al., PRL 107, 035006, 2011). The Omega experiment compressed the seed field up a thousand-fold, with fast implosion times shorter than magnetohydrodynamic (MHD) instability times and implosion pressures much greater than magnetic field pressures, yet transverse electron heat conduction could still be suppressed as~ $1/(1+\omega\tau_{ei}^2)$ with $\omega\tau_e > 1$.

Pre-magnetization of ICF capsules before implosion has many potential benefits at stagnation; in order of increasing initial B_{zo} needed: reduction of transverse electron heat conduction (~10-20 T minimum B_{zo} needed), improved energy deposition of alphas within the hot spot (especially when the hot spot ρR is lower than the alpha deposition range of 0.3 g/cm^2 - > 30-60 T needed), and possible suppression of RT instabilities due to field line tension (bending energy needing B_{zo} ~ 100 to 300 T, to be determined). For alpha gyroradius $r_{\Omega\alpha} < R_{hs}/2 \sim 12$ microns at peak compression (compressed $B_{stag} > 200$ MG), an estimated initial B_{zo} in the capsule of ~20-40 T is required, higher than the fields used in the initial Omega tests, but now achieved in recent magnet tests at LLNL.

Well developed 2D and 2D radiation hydrodynamic simulation codes have been used in the US, France, China and Russia to interpret ICF implosion data, but to fully understand the potential benefits of applied magnetic fields for future planned experiments with high magnetic fields, there is a need to develop numerically more robust versions of such codes that include the full set of magnetized plasma transport (MHD) equations [S. Braginskii, "Transport processes in a plasma" Reviews of Plasma Physics **1**, (1965)] that can numerically manage parameters (density, temperature and field) over a wide dynamic range for implosions that converge a factor of 30 in radius.