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Generation of Planetary Interior Conditions in the Laboratory Using Intense Heavy Ion Beams at FAIR

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The field of planetary physics has received a great boost due to the recent discoveries of extrasolar planets. Majority of these planets are believed to be gas giants like Jupiter, nevertheless a few Earth-like rocky planets named, super-Earths, have also been found. Due to the vast seismic data collected over the past many decades, the geologists have a
reasonable idea about the structure of the Earth core. It is believed that the Earth core is mostly comprised of Fe. Assuming an Earth-like internal structure, models have been developed to assess the physical conditions that may exist at the interior of the super-Earths of different masses. It has been shown that [1,2] for planet mass between 1 – 10 times Earth mass, the pressure could be in the range of 3.5 – 15 Mbar while the temperature may be in the range 6000 – 10000 K. It is thus important to understand the thermophysical and transport properties of Fe under these extreme conditions in order to study the planetary interiors. In this talk we present two-dimensional hydrodynamic simulations which show that using intense heavy ion beams that are going to be available at the FAIR accelerator in Darmstadt,
one can perform experiments to generate High Energy Density (HED) samples of Fe with the above physical conditions. These samples can be used to study the equation of state properties, thermal and electrical transport properties as well as the viscosity of HED Fe. This study exploits the proposed LAPLAS (Laboratory Planetary Sciences) scheme [3,4], which is based on a low-entropy compression of a sample material driven by an intense ion beam in a multi-layered cylindrical target. Intense laser-driven hard x ray (100's of keV) will be used as a
backlighter to enable imaging along the cylinder axis. This will provide a monitor of the hydrodynamic evolution of the target and will allow for absolute measurements of the final areal density reached in the sample. Previously, simulations of this scheme were done to produce HED samples of hydrogen [3] and water [4] to generate the extreme physical conditions that exist in the cores of hydrogen rich planets like Jupiter and Saturn as well as water rich planets like Uranus and Neptune,
respectively. We expect that these experiments will be very helpful in understanding the structures of the different type of planets in our solar system and elsewhere.

References

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