Generation of Physical Conditions Similar to Interior of Superearth Extrasolar Planets by Imploding Solid Iron in LAPLAS Experiments at FAIR *

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Due to the discovery of a huge number of Extrasolar planets of different types (gas giants, frozen water rich and earth like rocky planets) over the past two decades, the subject of planetary science has entered into a new very exciting era. This contribution presents numerical calculations using the LAPLAS experimental scheme [1-3] to implode solid Fe to physical conditions that are predicted to exist in the interior of Extrasolar rocky planets named ”Superearths” or ”Exoearths”. The target consists of a solid Fe cylinder having L = 4 mm and r = 0.2 mm that is enclosed in a W cylinder having an outer radius of 3 mm.

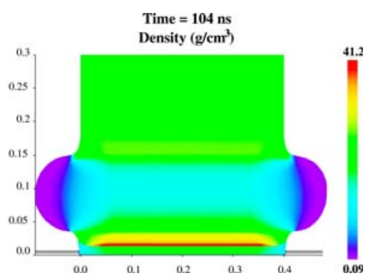

Figure 1: T vs time (Density distribution at the time of maximum compression 5×10^{11} ions.

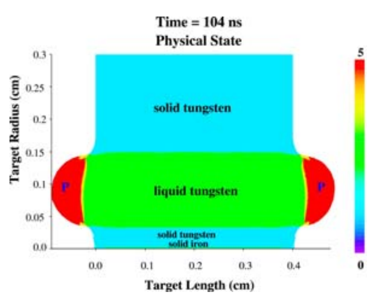

Figure 2: Phase state of the target corresponding to Fig. 1.

A hollow beam of 1 GeV/u U ions (that will be available at FAIR) that has an annular focal spot is used to implode the target. The beam intensity is considered to be 5×10^{11} ions per bunch where the bunch length is 50 ns. Numerical simulations have been done using the 2D hydrodynamic code, BIG2.

In Fig. 1 we present the target density at the time of maximum compression. It is seen that a shell of tungsten tamper with a density of about 40 g/cm^2 has been generated around uniformly compressed Fe. Fig. 2 shows the material phase corresponding to conditions presented in Fig. 1. It is seen that the compressed Fe and the compressed tungsten tamper are in solid phase whereas the tungsten region directly heated by the target is in liquid state.

* Work supported by the BMBF

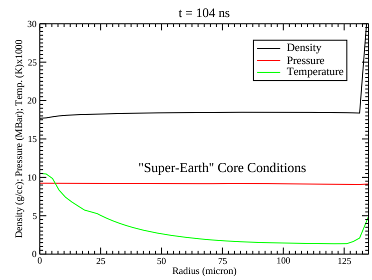

Figure 3: ρ, T and P vs r in Fe region using 5×10^{11} ions.

In Fig. 3 we plot the density, temperature and pressure vs radius in the iron region at L = 2 mm (target middle). It is seen that Fe has been compressed to twice the solid density where as the pressure is around 10 Mbar. These are conditions that are expected to exist in the interiors of huge earthlike Exoplanets.

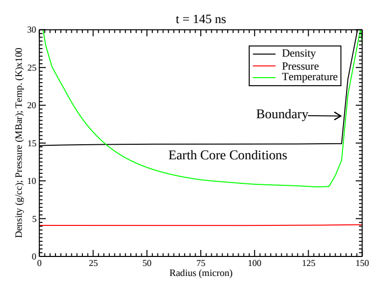

Figure 4: ρ, T and P vs r in Fe region using 2×10^{11} ions.

In Fig. 4 we plot the same parameters as in Fig. 3, but using a lower beam intensity of 2×10^{11} per bunch. In this case one achieves conditions similar to that in the earth core. LAPLAS experiment is a very efficient scheme to study planetary physics at FAIR.

References

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[3] N.A. Tahir et al., New J. Phys. 12 (2010) 073022.