Contribution ID: **50** Type: **Poster**

A numerical simulation of Gravitational Collapse of a Neutron star

Tuesday 20 March 2018 16:00 (1 hour)

Gravitational collapse of a star occurs when the internal pressure cannot sustain the gravitational forces. There are two essentially different mechanisms. One is the collapse due to the relativistic effects in the degenerate Fermi Gas, known in the form of Chandrasekhar mass limit, associated with the collapse of white dwarfs or core of the massive stars in advanced stage. Other is due to the general relativistic effects which lead to the appearance of event horizon forming black holes. Oppenheimer and Volkoff in 1939 showed for the first time that stars with mass greater then $0.7M_{\odot}$ using the Fermi gas of neutrons will not have stable configurations from Einstein field equations. Such a phenomena could happen also under Newtonian gravitation with a relativistic Fermi gas equation of state if we include the internal energy into the gravitational mass. In this study we will simulate numerically the gravitational collapse of a neutron star under the Newtonian gravitation of forces. We first formulate the variational formalism within the post-Newtonian gravitation, using the Lagrange coordinate system and derive the dynamic equations for the smoothed particle hydrodynamics (SPH). In this way, we also discuss non-spherically symmetric dynamics. The present study is a preparative work of SPH approach to solve the Oppenheimer-Snyder equations.

Summary

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Session Classification: Tuesday Posters