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Magnetothermal evolution of neutron stars with the new 3D code MATINS

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Abstract: Neutron stars are compact objects formed from the gravitational collapse of massive stellar cores. They are among the most extreme objects in the Universe, with central densities exceeding nuclear saturation density and magnetic fields that are the strongest known in nature. Rather than constituting a uniform class, neutron stars display a broad diversity in their observational properties, leading to their classification into several phenomenological sub-classes characterized by similar features. These sub-classes may represent distinct populations or different evolutionary phases within a unified framework.

Understanding the thermal and magnetic evolution of neutron stars is essential to uncover possible evolutionary connections among these sub-classes. It is also crucial for interpreting their spectral and temporal behavior and for placing constraints on the dense matter equation of state. To this end, a detailed numerical treatment of heat diffusion and magnetic field evolution is required, incorporating realistic microphysical inputs such as neutrino emissivity, thermal and electrical conductivity.

Moreover, to capture the effects of asymmetries—expected to produce non-uniform temperature distributions on the stellar surface—a full three-dimensional solution of the magneto-thermal evolution equations is necessary.

In this talk, I will present MATINS, our new 3D code designed to solve the magneto-thermal evolution of neutron stars with the most comprehensive microphysical treatment currently available.

Auteur: ASCENZI, Stefano (Gran Sasso Science Institute (GSSI))

Orateur: ASCENZI, Stefano (Gran Sasso Science Institute (GSSI))

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