STSM scientific report

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TITLE: **Dynamics of R-modes and cooling of young rapidly rotating pulsars**

During my visit at the Matej Bel University we worked with Dr. Kolomeitsev on the problem of the dynamics of r-modes in young rapidly rotating pulsars. The project was a continuation of our previous collaboration realized recently in two published papers [1,2], where we evaluated viscosities with account for strong medium modifications of the nucleon-nucleon interaction because of the softening of pionic degrees of freedom in the dense nucleon matter. Nucleon pairing effects were incorporated. Additionally we added to the viscosity a new term originated by the Schmid modes in the superconductor which we calculated recently. Direct Urca processes are switched off in our model, except for the most massive neutron stars. In the absence of the direct Urca processes, the most efficient are medium modified Urca processes and pair breaking-formation processes on neutrons and protons.

First, we found a frequency-temperature trajectory for young pulsars working with ansatz of Refs. [3,4] that r-mode amplitude saturates rapidly, and that medium modified Urca processes are fully responsible for the star cooling while the r-modes are responsible for internal heating. We compared our result with the results obtained in Ref. [4]. Then we introduced specific non-linear term in the differential equation describing the temporal dependence of the r-mode amplitude and studied the cases where the r-modes saturate at a constant value and where the amplitude first increases and then decreases with the passage of time.

Our model showed that in some interval of neutron star masses the neutron star cooling can be approximately described by the averaged neutrino emissivity $\sim T^8$ and the specific heat $\sim T$ during the relevant time interval. In this case, solving equations numerically we confirmed our analytic solution.

During the visit we also finalized the paper [5], where we demonstrated how the relativistic mean-field models can be appropriately stiffen for high densities in order to satisfy the maximum neutron star mass constraint without a change of the original equation of state for densities of the order of the nuclear saturation density. The developed scheme allows to improve the RMF models, which are well fitted to finite nuclei but do not fulfill the experimental constraint on the limiting neutron star mass.

The manuscript of the paper devoted to the r-mode dynamics is now in preparation.

[1] E.E. Kolomeitsev and D.N. Voskresensky,
Mechanism of r-mode stability in young rapidly rotating pulsars,
Eur. Phys. J. A50 (2014) 180

[2] E.E. Kolomeitsev and D.N. Voskresensky,
Viscosity of neutron star matter and r-modes in rotating pulsars,
Phys. Rev. C91 (2015) 025805

[3] B.J. Owen, L. Lindblom, C. Cutler, B.F. Schutz, A. Vecchio and N. Andersson,
Gravitational waves from hot young rapidly rotating neutron stars,
Phys. Rev. D58 (1998) 084020

[4] M.G. Alford and K. Schwenzer,
Gravitational wave emission and spindown of young pulsars,
Astroph. J. 781 (2014) 26

[5] K.A. Maslov, E.E. Kolomeitsev and D.N. Voskresensky,
Making a soft relativistic mean-field equation of state stiffer at high density,
arXiv:1508.03771

24.08.2015 D.N. Voskresensky