Protoneutron Star rotating with keplerian frequency with in relativistic mean field model

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Introduction

Protoneutron star is a result of the gravitational collapse of a massive stellar core. Initially, it can have large radius of about 100 km and a temperature of 50-100 MeV. The Protoneutron star may be born with a large rotational kinetic energy and initially it will be differentially rotating. Due to the violent nature of the gravitational collapse, the PNS pulsates heavily, emitting significant amounts of gravitational radiation. After a few hundred pulsational periods, bulk viscosity will damp the pulsations significantly. Rapid cooling due to deleptonization transforms the PNS, shortly after its formation, into a hot compact star of T $\sim$ 10 MeV [1].In the present work the keplerian configurations of rapidly rotating protoneutron stars have been computed in framework of general relativity by solving the Einstein field equations for stationary axisymmetric space time (e.g. see Ref.[2] and references therein). The numerical calculations have been performed by employing the Rotating Neutron Star (RNS) code [3]. In the present work we have employed a set of parameterizations of the Extended Relativistic Field Model(ERMF) as BSR1 - BSR21 [4, 5], generated by varying the ω meson self-coupling ζ and neutron skin thickness Δr for the ^{208}Pb nucleus.

The mass and radius have been calculated by employing various parametrizations of extended RMF model at 0, 5 and 10 MeV temperature of nuclear dense matter. In this paper we extended the previous work [6] and computed the mass at keplerian frequency using the relation

$$M_\nu = a1 * \nu^2 - a2 * \nu + a3 * M_{static} \quad (1)$$

and compaired it to the value obtained from RNS code at temperature of 0, 5 and 10 Mev.

Result and discussion

It is found that keplers frequency decreases with rise in temperature and also decreases with the increase in neutron skin thickness(Δr) of ^{208}Pb from 0.16 to 0.28 fm. The kepler frequency further decreases on increase of value of ω-meson self-coupling ζ from 0.00 to 0.06. We varified the imperical relation 1for all the perametrisation of ERMF as given in table I. The best fit values which computed the keplerian frequency are computed to be a1 = 5.94 x 10^{-7}, a2 = 4.03 x 10^{-4} and a3 = 1.26 From table it is clear that all the imperical relation is followed by all the perametrizations of ERMF model at all temperatures.

References

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TABLE I: The mass of rotating PNS, rotating with keplerian frequency at a temperature of 0, 5 and 10 MeV is presented for BSR1, BSR7, BSR8, BSR14, BSR15 and BSR21 parametrization of ERMF model as calculated from imperical relation 1 and as calculated from the RNS code

Perametrization	ζ	Δr (fm)	T MeV	Kepler frequency Hz	M_{max} from imperical relationship M$_o dot$	M_{max} from RNS code M$_o dot$
BSR1	00	0.16	0	1487.82	2.9939	2.9933
			5	1302.80	3.2075	3.2648
			10	1194.45	3.2367	3.3917
BSR7	00	0.28	0	1461.41	2.9582	3.0130
			5	1215.45	3.1517	3.4252
			10	1168.52	3.1820	3.4347
BSR8	0.03	0.16	0	1385.52	2.5234	2.3699
			5	1195.57	2.7018	2.6677
			10	1089.61	2.7411	2.7635
BSR14	0.03	0.28	0	1365.16	2.4912	2.3386
			5	1113.48	2.6662	2.8059
			10	1061.30	2.7001	208218
BSR15	0.06	0.16	0	1374.07	2.3485	2.0858
			5	1182.52	2.4718	2.3862
			10	1076.09	2.4727	2.4519
BSR21	0.06	0.28	0	1336.05	2.3195	2.0910
			5	1096.93	2.4752	2.5440
			10	1032.34	2.4843	2.5599

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