The TOV Limit as an Illusion

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Abstract: It is assumed that the TOV limit (about 2.4 solar masses) is an upper limit to the masses of non-rotating neutron stars (NSs). In fact, masses of NSs are up to 24.81 solar masses (the upper limit is for the neutron black hole (NBH)). Here we show that the significant electromagnetic darkening of NSs for masses close to TOV limit is the result of the weak interactions of the spin-1 dark-matter (DM) loops with baryon plasma at the equators of the NSs. The second darkening should be observed for masses close to 19.5 solar masses – it is for the spin-2 DM loops. Darker should be also black holes composed of the NBHs.

Introduction and motivation

We showed within the Scale-Symmetric Theory (SST) [1], [2] that there were created three different dark-matter (DM) objects but today only abundance of the DM loops with different radii and with the invariant mass $M_{DM\text{-}loop} = 2.0796 \cdot 10^{-47}$ kg $\approx 1.2 \cdot 10^{-11}$ eV is very high [3]. The spin speed of the DM loops in the rest is equal to the speed of light in "vacuum" $c \approx 3 \cdot 10^{8}$ m/s so it is the invariant quantity too. This leads to a conclusion that spins of DM loops are directly proportional to their radii. From the formula for angular momentum of DM loop

$$M_{DM\text{-}loop}\, c\, R^*_{DM\text{-}loop} = \hbar \,, \tag{1}$$

we obtain that radius of the spin-1 DM loops is $R^*_{DM\text{-}loop} = 16.916$ km.

On the other hand, SST shows that due to the very strong short-distance entanglement, destruction of the baryon cores is impossible so the TOV limit should be an illusion [1]. Mass of the neutron black hole (NBH) is $M_{NBH} = 24.81$ **solar masses** and it has a radius of $R_{NBH} = 36.64$ km [2]. On the assumption that mass density of all neutron stars and the NBH are the same, we obtain that mass of a neutron star, $M_{Threshold,A}$, with the radius $R^*_{DM\text{-}loop}$ is

$$M_{Threshold,A} = M_{NBH} (R^*_{DM\text{-}loop} / R_{NBH})^3 = 2.441 \text{ solar masses} \,. \tag{2}$$

This mass is very close to the TOV (Tolman-Oppenheimer-Volkoff) limit. For example, the X-ray object in 4U 1700-37 has mass 2.44 ± 0.27 solar masses and it is assumed that it is one of the most massive neutron stars [4].

SST shows that Nature tries to duplicate the characteristic physical properties on its different levels. Then abundance of the spin-1 DM loops in the Universe should be highest because such spin have the SST Einstein-spacetime components [1].

Assume that the DM loops with the radius of 16.916 km interact due to the weak interactions with baryon plasma on equators of the neutron stars with a mass of ~ 2.44 **solar**

masses. It causes that the cores of baryons, due to the confinement or/and due to the weak interactions via the virtual electron-positron pairs [1], are dragged by the entangled components of the DM loops. Since the spin speed of the DM loops is higher than the spin speed of the neutron star at its equator, the baryon plasma is accelerated to velocities higher than the first cosmic velocity and therefore moves away from the equator of the neutron star. We can see that the DM loops overlapping with the equator significantly decrease number density of thermonuclear interactions (nuclear plasma is effectively scattered) so neutron stars with masses close to 2.44 **solar masses** should be much darker so their detection is difficult.

From formulae (1) and (2) follows that the second darkening should be observed for masses close to 19.53 **solar masses** – it is for the spin-2 DM loops. Notice that abundance of the spin-2 DM loops should be lower than the spin-1 DM loops.

It is obvious that significant electromagnetic darkening should be characteristic also for black holes composed of the NBHs.

There is a graphic that shows a separation of masses of SNs detected through electromagnetic observations from masses of black holes detected through electromagnetic observations and from masses of black holes measured by gravitational-wave observations [5]. There are two thresholds – just for about 2.4 and 19.5 solar masses.

References

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[2] Sylwester Kornowski (14 February 2019). “Foundations of the Scale-Symmetric Physics (Main Article No 2: Cosmology)” http://vixra.org/abs/1511.0223

[3] Sylwester Kornowski (24 October 2020). “The Three Dark-Matter Objects” http://vixra.org/abs/2010.0196

[4] C. Jones, *et al.* (1973). “Evidence for the Binary Nature of 2U 1700-37” *The Astrophysical Journal*, **181**: L43

[5] Frank Elavsky, Aaron Geller (LIGO-Virgo). Updated 2 September 2020 www.ligo.caltech.edu/image/ligo20200623a