

## Original Research Article

# Cosmic Baby and the detection of New Compact Star- the “ Triaxial Star” : A Possibility

**Abstract** : The “Triaxial Star” first proposed by S. Chandrasekhar in 1969 but till date this is not yet detected. The Cosmic Baby i.e. Swift J1818.0-1607 is the youngest magnetar. It's characteristic age is ~300 years having superfast spin period ~ 1.36 s and strong surface dipole magnetic field ~  $3 \times 10^{14}$  G. Taking into account three facts:

- i) The ambipolar diffusion in the neutron star core is expected to be the dominant mode of field decay in the early evolution of magnetar ( as long as the age much less than ~  $10^4$  yrs) ;
- ii) Magnetars's field decay is negligible as long as the core temperature is few times of  $10^8$  K (i.e.  $< 10^9$  K) ;
- iii) The coupling between the decay of internal magnetic field and the neutron star cooling is so strong at the early phase of Magnetar that it significantly slows down both processes but interior magnetic fields remain so strong that core temperature stays higher than several times  $10^8$ K for thousands years (at least  $10^3$  yrs) as proposed by Dall'Osso et al [40]

we suggest swift J1818.0-1607 is a triaxial magnetar i.e. simply Triaxial Star. The fast spin period and interior ultra-strong magnetic field turn this baby magnetar as a unique compact object having spontaneously broken axial symmetry and offer it to the astronomers as a potential source for detecting and measuring the properties of triaxially deformed neutron star ( i.e. Magnetar) or triaxial star. Significance of our study is — continuous observation thus provides an opportunity for (a) detection of physical existence of Triaxial Star (b) understanding the evolution of the magnetic field from strong magnetic field to ultra-strong magnetic field of a neutron star and a magnetar and (c) the bizarre properties of new baby magnetar. This author encourages the GW community to search the electromagnetic counterparts during their observation of compact objects.

**Key Words:** Gravitational Waves, Triaxial star, Neutron Star, Pulsar, Magnetar

## 1. Introduction

The idea of “Triaxially deformed” star was first proposed by S. Chandrasekhar in 1969 [1]. The classical solution of Maclaurin spheroids and Jacobi ellipsoids for self-gravitating and uniformly rotating, incompressible fluids in equilibrium provide us two models of rapidly rotating stars.

When the rotation of an equilibrium configuration is increased, the sequence of triaxial Jacobi ellipsoids branches off from that of the axisymmetric Maclaurin spheroids such that the ratio of kinetic (T) to gravitational (W) energies reaches  $T / |W| \sim 0.14$  [2]. This means that triaxially deformed rotating compact stars (or simply triaxial stars) are rather than ‘ellipsoid’ because the configurations are no longer an exact ellipsoid in relativistic gravity or for compressible fluids. In the view of relativistic astrophysics this triaxial model is very important by including compressibility of the fluid, for modeling the realistic neutron star as an axisymmetric and uniformly rotating configurations associated with equation of state (EoS) of high density nuclear matter [3, 4].

Considering the triaxial configurations possessing the tri-planar symmetry w.r.t. three orthogonal x, y, z planes for relatively stiff (piecewise) polytropic equation of state (EoS) Uryū et al [5] found supra-massive triaxial solutions the masses of which exceed the maximum mass of the spherical solution but are always lower in comparison to those of axisymmetric equilibrium. The fact to be noted they obtained are :

- a) The difference in the maximum masses of triaxial and axisymmetric equilibrium solutions depends sensitively on equation of states (EoSs) ;
- b) In the case when this difference turns out to be only 10%, then it will be treated as a strong evidence that the EoS of high density matter in the core of neutron stars becomes substantially softer [ 5].

Another important fact regarding the criteria for the star collapsing to black hole [7] is that the supernova fall back accretion may spin up a newly born neutron star having a strong magnetic field ( $B$ )  $\leq 5 \times 10^{14}$  G as fast as  $T / |W| \sim 0.14$  for 50 – 200 s until the star collapses to a black hole. This means there is a possibility that a triaxially deformed compact stars, like above mentioned newly neutron star, may be formed transiently from massive stellar core collapse. Once such triaxial star is formed, emission of enormous amount of gravitational waves then provides us an opportunity to extract properties of high density nuclear matter. Considering the typical value [6] of the amplitude of gravitational waves produced from triaxial stars and using a realistic excess cross-power search algorithm

$$h \sim 9.1 \times 10^{-21} (30 \text{ Mpc} / D) (M / 1.4 M_{\odot})^{3/4} (R / 10 \text{ Km})^{1/4} f^{-1/5} \dots\dots(1)$$

where D, M, R and f are the distance to source, the source mass, the mean radius, and the wave

(2)

frequency in Hz , respectively. Piro and Thrane [8] estimated the detectability of gravitational waves produced by triaxially compact stars under the fall back accretion scenario for Advanced LIGO detector [ 9]  $\sim 17$  Mpc.

Deformation of neutron star or magnetar by its internal ultra-strong core magnetic field can offer it as a triaxial compact star [ 10-12]. In this paper we study the triaxiality of the magnetar Swift J1818.0-1607 considering the stability of its ellipticity and the effect of internal strong core magnetic field.

## 2. Cosmic Baby

On 12<sup>th</sup> March 2020 at 21:16:49 UT the Swift Burst Alert Telescope (BAT) on board the Neil Gehrels Swift Observatory [13] detected a typical characteristics of short burst from magnetar [14]. 64 seconds afterwards observation by the Swift X-ray Telescope (XRT) finally detected a new uncatalogued x-ray source, so called Swift 1818.0 – 1607 which is presently known as Cosmic Baby. The important parameters of this cosmic baby , obtained from the timing analysis of early observations at the time of discovery, are shown in table I.

**Table I :** Various early observed / measured parameters of Swift J1818.0 – 1607

Instruments	Observation based on	Typical properties	Value	Reference
BAT Radio Telescope	9 ms hard X-ray burst and long-lived outbursts	Characteristic age (shortest known )	$\sim 240$ years	Esposito et al [15]
		Surface magnetic field	$\sim 2.7 \times 10^{14}$ G	
		Dipolar magnetic field at poles	$\approx 7 \times 10^{14}$ G	
		Spin down Luminosity ( $\dot{E}_{\text{rot}}$ )	$\sim 1.4 \times 10^{36}$ erg.s <sup>-1</sup>	
XMM Newton Telescope		Luminosity	$\sim 8 \times 10^{34}$ erg.s <sup>-1</sup>	Enoto et al [16]
		Coherent periodicity of x-ray signal	1.36 s	
Sardini Radio Telescope	Radio observation	Spin period derivative	$\sim 8.2 \times 10^{-11}$ s.s <sup>-1</sup>	Champion et al [17]
		Period derivative	$\sim 9 \times 10^{-11}$ s.s <sup>-1</sup>	
		Spin Period	0.7333920 s	

After a series of observations through various telescopes (such as TMRT, NICER ) at several

(3)

wavelengths till July 27, 2020 some confirmed parameters of the cosmic baby magnetars were available. For example: Rotation / spin period derivative is  $\sim 3.74 \times 10^{-11}$  s<sup>-2</sup>, surface dipole magnetic field  $\sim 3 \times 10^{14}$  G, spin down luminosity  $\sim 1.1 \times 10^{36}$  erg. S<sup>-1</sup>, etc. Although Chandra

Observatory [18] began its observation to swift J1818.0 – 1607 less than a month after the discovery of cosmic baby but its observations gave the astronomers the first high resolution view of the cosmic baby in x-rays. Still there is a lot of variation almost in all parameters of the cosmic baby properties.

### 3. Ellipticity of Cosmic Baby Magnetar Swift J1818.0-1607

To explain the properties of transient sources of gamma ray i.e. Soft Gamma Repeaters (SGRs) Robert Duncan and Christopher Thompson [19] first proposed the existence of Magnetars in 1992. Magnetars are isolated young Neutron Stars having intense magnetic fields which power a wide variety of high energy-emission from giant flares to fast radio bursts. The basic idea regarding these peculiar high energy sources could be the ultra-strong magnetized neutron stars, magnetars with surface (dipole) fields in the range  $10^{14} - 10^{16}$  G and internal magnetic fields  $> \sim 10^{16}$  G ( at least one order of magnitude stronger ) [20,21]. As the density of the neutron star core is beyond the density  $\sim 10^{15}$  g.cm<sup>-3</sup>, it creates an anisotropic nature of the compact object [22] i.e. internal pressure can be decomposed into two parts: the radial pressure ( $p_r$ ) and the transverse pressure ( $p_t$ ) where  $p_t$  is the orthogonal to  $p_r$ . This pressure anisotropy affects the physical properties, stability and structure of the stellar matter [23]. The ultra-strong internal magnetic field of the stellar matter can also create anisotropic pressure i.e. the deformation of spheroidal shape of rotating neutron star and emission from it due deformation.

In searching the strong Gravitational Wave (GW) emission Cutler [24] first pointed out the internal field structure of a neutron star becoming an effective, efficient source of GW emission. According to him a magnetically distorted neutron star, i.e. a neutron star with a strong internal toroidal field, turn into a prolate shape that offer the best chance of being a strong GW emitter. Thus, the ellipticity of the magnetic deformation ( $\epsilon_B$ ) in the shape of stellar object has crucial role in the strong GW source. In other word, the triaxiality of the stellar body —its dependence on the internal strong magnetic field strength, decay of the field strength, dynamical shape transition to a triaxial ellipsoid configuration.

A magnetar is a slowly rotating isolated neutron star having very strong magnetic field ranging  $10^{16} - 10^{18}$  G and even more upto  $10^{20}$  G [25] in its interior. In general, a magnetar is a triaxial stellar body [26], particularly in new born phase. Its internal ultra-strong magnetic field (i.e. the toroidal magnetic field is greater than at least one order of its surface dipolar magnetic field) is estimated by inferring from the geometric distortion of the neutron star (or magnetar) caused by strong toroidal magnetic field. Therefore, limits on the ellipticities of magnetars can be used to

(4)

constrain the toroidal magnetic field as a period or duration of GW emission. So, if the field is dipolar, then hydro-magnetic stresses, arising from non-radial gradients of the super-strong internal magnetic field, deform the magnetar (i.e. between the magnetic poles and the equator )

and the fractional difference ( $\epsilon$ ) between the principal moments of inertia can be expressed as [26,27,28]

$$\epsilon \sim \delta\rho R^5 / I_1 \approx 2 \times 10^{-9} (B_{\text{int}} / 10^{10} \text{ T})^2 \dots\dots\dots (2)$$

where  $\delta\rho$  = induced matter-density perturbation

$$\sim B_{\text{int}}^2 / \mu_0 C_s^2 ,$$

$R$  = the stellar radius,

$C_s$  = the isothermal sound speed ( $= 3^{-1/2} c$ ,  $c$  being the velocity of light),

$B_{\text{int}}$  = the characteristic magnitude of the internal magnetic field

- i)  $\approx B_o$ , if the internal magnetic field is confined to the stellar crust,
- ii)  $> \sim B_o$ , if it is generated deep inside the star (i.e. convective dynamo model [29],
- iii)  $B_{\text{int}} < \sim 10^9 \text{ T}$  in the case of rotation powered pulsars

According to Melatos [26] a) the hydrodynamic deformation in a magnetar is much larger in comparison to the elastic deformation arising from shear stresses in the crystalline stellar crust of a rotating neutron star; b) the principal axes of inertia in a rotating neutron star are oriented arbitrarily w.r.t.the magnetic axis of the external magnetic dipole field where as in the case of magnetar the magnetic axis is approximately parallel to one of the principal axes of inertia (say  $e_3$ ) i.e. the alignment of magnetic axis is not exact to inertia axis due to the complicated structure of the internal field near its generation site (i.e. in other word, a non-axisymmetry state remains).

#### 4. Origin and decay of core magnetic field of Swift J1818.0-1607

Idealizing the magnetar as a neutron star with the shape of slightly deformed, homogeneous ellipsoid and having a small ellipticity

$$\epsilon = (I_1 - I_2) / I_3 \dots\dots\dots (3)$$

where  $I_1, I_2, I_3$  are the principal moments of inertia of the neutron star such that  $I_3$  is assumed to be aligned with the spin axis then using eqn. (3) we obtain the following constraint on the magnetar ellipticity [30] as

$$(5)$$

$$|\epsilon| < (5 / 3G)^{1/2} \{ C R^3 P_o B_{\text{dipole}} / 2^4 \pi I \}$$

$$\cong 3 \times 10^{-4} (B_{\text{dipole}} / 10^{14} \text{ G}) (P_o / 1\text{ms}) \dots\dots\dots(4)$$

with fiducially standard neutron star properties of  $I=10^{45} \text{ g.cm}^2$ ,  $R = 10 \text{ km}$ ,  $P_o =$  initial spin period and the angle between the spin axis and the principal axis of the neutron star distortion =  $\pi/2$  [31].

If we assume that magnetar's internal toroidal magnetic field component ( $B_{\text{toroidal}}$ ) is the main cause of neutron star deformation then we can constrain the average value of this component by the relation [24]

$$|\epsilon| \sim 1.6 \times 10^{-4} (B_{\text{toroidal}} / 10^{16} \text{ G})^2 \dots\dots\dots(5),$$

and  $B_{\text{toroidal}}$  as [30]

$$B_{\text{toroidal}} < \sim 1.4 \times 10^{16} \text{ G} (B_{\text{dipole}} / 10^{14} \text{ G})^{1/2} (P_o / 1 \text{ ms})^{1/2} \dots\dots\dots(6)$$

Considering the observed dipolar magnetic field strength  $B_{\text{dipole}} = 7 \times 10^{14} \text{ G}$  and spin period  $P_o = 1.36\text{s}$  of the Swift J1818.0-1607 we estimate the ultra-strong internal toroidal field strength  $B_{\text{toroidal}} < \sim 10^{18} \text{ G}$ . This value is consistent with the value  $10^{17} - 10^{18} \text{ G}$  in the case of newly born proto-neutron stars [32 – 34] and also supports the model proposed by Dall'Osso et al [35] that the internal magnetic field must be a very large initial value ( $> \sim 10^{16} \text{ G}$ ) for the internal magnetic field decay.

The decay of Core Magnetic field

Studies [36,37] of magnetic field decay in neutron star core hint three separate processes — ohmic dissipation, ambipolar diffusion and Hall drift are involved which affect the evolution and dissipation of magnetic fields in magnetar interior. In particular, ohmic dissipation and ambipolar diffusion are directly active in dissipation while Hall drift is active indirectly. Further studies [38,39] also indicate the conservation of total energy remains almost same after the Hall drift i.e. due to Hall diffusion a new equilibrium configuration with smaller total energy will appear in the magnetar interior. But initial stable magneto-hydrodynamic configurations remain close to the new equilibrium configuration as per results found in their studies. Even, the ambipolar diffusion in the neutron star core is expected to be dominant mode of interior field decay as long as early phase evolution ( i.e. ages much less than  $\sim 10^4$  yrs) of magnetar is concerned.

Another important result was obtained in ref [38,39] regarding ambipolar diffusion at high temperature in neutron star ( i.e. magnetar) core. Ambipolar diffusion actually drives a slow motion of charged particles (situated among neutrons in the neutron star core) which is opposed

by both particle friction and chemical potential gradients in the stable neutron star medium. Depending on their effect on chemical composition two modes of ambipolar diffusion are active inside the core : a) solenoid mode —counteracting only by particle friction without perturbing chemical equilibrium b) irrotational mode — perturbing the chemical equilibrium but can not evolve on time scales shorter than the  $\beta$ -reaction time-scale. As the neutron star (i.e. magnetar) core magnetic field  $< \sim 10^{18}$  G (which is  $> \sim 10^{16}$ G) the temperature in the magnetar core material will be  $> 10^9$  K. In this case the field decay is not frozen. This means an equilibrium condition between heating and cooling in the high-Temperature regime may appear.

Using the relation for heating rate per unit volume through field decay

$$dU^+ / dt = (B^2 / 4\pi t_{\text{decay}}^{\text{(early)}}) \approx 3.69 \times 10^{19} \{ B_{16}^4 / T_9^2 (\rho_{15})^{2/3} \} \text{ erg.cm}^{-3} . \text{s}^{-1} \dots\dots\dots (7)$$

and the relation for cooling rate per unit volume through modified URCA reaction

$$dU^- / dt \cong 9.6 \times 10^{20} . (T_9)^8 . (\rho_{15})^{2/3} \text{ erg.cm}^{-3} . \text{s}^{-1} \dots\dots\dots(8)$$

and then equating the two rates Dall’Osso et al [40] found the equilibrium temperature as

$$T_{\text{eq}} \cong 6.6 \times 10^8 . (B / 10^{16} \text{ G})^{2/5} . (\rho_{15} / 0.7)^{2/3} . (L / 2 \text{ km})^{-1/5} \text{ K} \dots\dots\dots(9)$$

Where  $B_{16}$ ,  $T_9$  ,  $\rho_{15}$  are in their usual notations, ‘L’ and ‘a’ are the characteristic scale of variation of the Lorentz force and the chemical potential, respectively, with  $(L/a) \approx 9.6 T_9^4 (\rho_{15})^{-1/3} (L / 2 \text{ km})$  [37]. Comparing the obtained  $T_{\text{eq}}$  with the transition time  $T_{\text{tr}} \approx 5.73 \times 10^8 (\rho_{15} / 0.7)^{1/12} \text{ K}$  ( i.e. when  $\beta$ -reaction are very efficient in deleting the chemical equilibrium imbalance ) they found  $T_{\text{eq}}$  is higher than  $T_{\text{tr}}$  ( i.e.  $T_{\text{eq}} > T_{\text{tr}}$  ) at magnetar interior core field environment where field decay occurs on the same time scale in both active modes. This means that magnetar core fields larger than that would be able to i) dissipate enough energy as well as ii) to balance neutrino cooling in the early phase under the effective solenoidal and irrotational modes are still degenerate. It can be said that the field decay is negligible as long as the temperature is high enough ( e.g.  $> T_9$  ) when the time scale of field decay occurs on the same time scale in both two modes. The significance of ambipolar diffusion is that it becomes active soon after the formation of magnetar and can prevent the cooling of magnetar core below a temperature  $\sim 10^9$  K for a period of thousands yrs ( at least  $10^3$  yrs ) [40]. This means the decay of an internal magnetic field  $> \sim 10^{16}$  G couples with the magnetar cooling at the early stage.

## 5. Ellipticity and Triaxiality of Swift J1818.0-1607

Theoretically, a rotating neutron star will break its axial symmetry spontaneously when rotational kinetic energy to gravitational binding energy ratio i.e.  $T / |W|$  exceeds the critical

value. A newly born rotating compact star can also achieve higher value of  $T / |W|$  when it is born from core collapse supernova. In the case of triaxial neutron star the ratio  $T / |W|$  is essentially constant along with the triaxial sequence for higher compactness [41]. Till date thirty magnetars have been discovered excluding this swift J1818.0-1607. For these 30 magnetars their spin / rotational periods range 2 – 10 s and surface dipolar fields (calculated from the periods, period derivatives ) are  $10^{13} - 10^{15}$  G [42]. But Jawor and Tauris [43] showed that initial period of magnetar must be less than 2s. Analysis of observed data indicates magnetars are young and most of them having characteristic spin down ages of less than  $10^4$  years [44]. Since they are slow rotator, so spin down energy losses can not power their emission. Alternate source is believed to be the dissipation and re-arrangement of their magnetic energy. Magnetar interior structure specially equation of state (EoS) and the cooling process in the simultaneous presence of high density, strong gravity, and strong magnetic field is important in determining the deformation in shape as well as triaxial value of the magnetar [45 – 47 ].

Numerical simulations show a newly born magnetar will born with a strong magnetic field and a rapid rotation [48,49] which lead to the stellar deformation. As a result a magnetar can emit observable gravitational waves i.e. a baby magnetar will spin down due to a magnetic dipole torque as well as gravitational wave quadrupole radiation. Spin down evolution of the magnetar also produces electro-magnetic radiation. In other words, the dynamic evolution of magnetar spin down provides a relation to the theoretical breaking index (n) such that

- a)  $n = 3$  when magnetic dipole radiation (i.e. electromagnetic phenomena ) dominates the spin down of the magnetar ;
- b)  $n = 5$  when the GW radiation dominates the magnetar spin down.

On the other hand, the comparison between the observed spin down light curves and their related models provide us an opportunity to constrain the initial spin period ( $P_o$ ), dipole magnetic fields ( $B_{dipole}$ ) and the ellipticity ( $\epsilon$ ) of the neutron star (i.e. magnetar). For example, magnetars with initial period  $P_o \sim 1$  ms and surface dipole magnetic field  $B_{dipole} \sim 10^{14} - 10^{15}$  G usually have the ellipticity  $\epsilon \sim 10^{-3}$ . But theoretical value of the minimum rotation period of the magnetar is  $\sim 0.3 - 0.5$  ms [50]. The best fitting relations [51] are

$$\log \epsilon = 3.79^{+0.52}_{-0.43} + (2.19^{+0.17}_{-0.15}) \log P_o \dots\dots\dots (10)$$

$$\text{and } \log \epsilon = -22.50^{+2.15}_{-2.22} + (1.29^{+0.15}_{-0.14}) \log B_{dipole} \dots\dots\dots(11)$$

suggest that

- a) magnetar having a stronger magnetic field and / a slower spin period corresponds to the longer ellipticity;
- b) a longer rotation period corresponds to possession of a stronger magnetic field;

c) the neutron star deformation is related to its surface dipole magnetic field to some extent.

But it is argued [52,53] instead of dipole magnetic field neutron star deformation may be induced by a strong internal magnetic field ( $B_{\text{int}}$ ) in the stellar core through the relation

$$\epsilon \approx 10^{-8} (B_{\text{int}} / 10^{12} \text{ G}) \dots\dots\dots (12)$$

This relation hints the possession of a very strong internal magnetic field (i.e.  $B_{\text{int}} \sim 10^{16} - 10^{17}$  G) is needed in order to obtain the ellipticity  $\epsilon \sim 10^{-3} - 10^{-4}$  and also the required strength of the internal core magnetic field which should be at least 1 – 2 order of magnitude greater than the surface (i.e. external ) magnetic field ( $B_{\text{dipole}} \sim 10^{15}$  G).

The Triaxiality of Swift J1818.0-1607

At the time of its discovery on 12<sup>th</sup> March 2020 the Swift J1818.0 – 1607 was appeared to the astronomers as a new un-catalogued x-ray source. Presently it is a confirmed magnetar [52]. The follow up observations suggest the following properties :

- i) rotational period = 1.36 s
- ii) surface dipolar magnetic field =  $3 \times 10^{14}$  G
- iii) surface magnetic field at poles =  $7 \times 10^{14}$  G
- iv) spin down luminosity  $\sim 1.1 \times 10^{36}$  erg.s<sup>-1</sup>
- v) characteristic age  $\sim 300$  years

Using equ. (4), (5), (6) and (12) and with the above parameters as input we calculate the ellipticity, internal core magnetic field of Swift J1818.0-1607 and found  $\sim 9 \times 10^{-3}$  and  $8.9424 \times 10^{17}$  G, respectively.

Numerical study [53] of magnetized deformation of neutron stars shows an interesting consequence for neutron stars with low masses i.e. the effect of magnetic field is more prominent for internal magnetic field  $B_{\text{int}} > 4 \times 10^{18}$  G. According to Rizaldy and Sulakseno [53] the balance between the gravity and magnetic field is significantly different for different directions in the case of small mass rather than massive neutron star. Even the gravity pull of magnetic field on the z-axis is significantly more than for the other axes resulting which oblate-shape appears in the low mass neutron stars. In the case of massive neutron star this oblate shape is very less in comparison to that of less massive. In other words, we can say internal toroidal magnetic field is more effective than the poloidal field. The deformation associated to the poloidal field ( $B_p \approx 10^{14}$  and  $10^{15}$  G) and the corresponding correction in ellipticity (i.e.  $\sim 10^{-4} - 10^{-2}$ , respectively) is negligible [54].

In this study we consider the effect of toroidal magnetic field only although the recent view of magnetized deformation of neutron stars (i.e. magnetars ) is due to the effect of both the

toroidal and the poloidal magnetic fields i.e. a mixed magnetic field. Our main purpose is to check the ellipticity of the deformed neutron star i.e. magnetar Swift 1818.0 – 1607 and its stability. In a comparative analysis pulsars and magnetars Heras [55] found the initial magnetic fields in the interior of nascent neutron stars lie in the range  $10^{14} - 10^{16}$  G in realistic case. As ambipolar is active that prevents both the decay of interior magnetic fields and cooling of the neutron star i.e. magnetar (as the effect is same and applicable for magnetars as well as neutron stars also ) such that magnetar core temperature stays higher than several times  $10^8$  K for a period of few thousands of years ( at least  $10^3$  years) . This ellipticity of new born magnetar might not be changed too much during the period of thousand years. As the characteristic age of the Swift J1818.0 – 1607 is only  $\sim 300$  years i.e. the baby phase still compare to thousands years it will definitely exhibit triaxility i.e. triaxial behavior at least up to its age 1000years.

The estimated ellipticity of this magnetar lies within the range for triaxiality and its ellipticity will remain on that value for exhibiting triaxial nature for several thousands years. We thus propose that the Swift J1818.0 – 1607 is a triaxial magnetar or simply a triaxial star.

## 6. Conclusion

Newly born rotating neutron star can break their axial symmetry spontaneously if the ratio  $T / |W|$  exceeds some threshold value. Magnetars are classified as a rare class of relatively slow rotating neutron stars that possess very strong magnetic fields. As a non-dissipative mechanism a magnetic field with a component parallel to the rotation axis breaks circular conservation and introduces symmetry breaking spontaneously. The swift J1818.0-1607 is a baby magnetar of characteristic age of  $\sim 300$  years, having very strong internal core magnetic field  $\sim 8.9424 \times 10^{17}$ G. It is the fastest among the detected 31 magnetars having spin or rotational period  $\sim 1.36$  s. Its magnetic fields are not aligned with the rotational axes. The above properties of the swift J1818.0-1607 indicate that it is an ideal triaxial magnetar (compact object) where detection of a triaxial star and its bizarre properties can be tested / studied. Its internal core magnetic field, though too much strong, yet have ( at least) a slow decay mode through ambipolar diffusion which becomes active soon after formation (birth). As this process can prevent the cooling of the magnetar core below a temperature of few times of  $10^8$  K (i.e.  $< 10^9$  K) for thousands of years, continuous observation of Swift J1818.0 – 1607 will thus offer us an opportunity for understanding our knowledge of the evolution of magnetic fields of magnetars.

As the rotational period of this magnetar is 1.36s i.e. within the range 1 – 10s, the frequency of the emitted continuous gravitational waves would be very low [56,57] this author encourages the Gravitational Wave Community to observe this triaxial baby magnetar (i.e. the swift J1818.0-1607) continuously during their observation of compact objects through electromagnetic counterparts.

**Data Availability Statement :** Data sharing not applicable as no datasets were analysed.

**Ethical conduct :** Not applicable

**Reference :**

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