***LETTERS TO PROGRESS IN PHYSICS***

# Book Review: "Inside Stars. A Theory of the Internal Constitution of Stars, and the Sources of Stellar Energy According to General Relativity"

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This book provides a general relativistic theory of the internal constitution of liquid stars. It is a solid contribution to our understanding of stellar structure from a general relativistic perspective. It raises new ideas on the constitution of stars and planetary systems, and proposes a new approach to stellar structure and stellar energy generation which is bound to help us better understand stellar astrophysics.

The book "Inside Stars. A Theory of the Internal Constitution of Stars, and the Sources of Stellar Energy According to General Relativity" by Larissa Borissova and Dmitri Rabounski [1] provides a general relativistic theory of the internal constitution of liquid stars.

The generally accepted model of stellar constitution considers stars to be high-temperature gaseous plasmas obeying the ideal gas equation of state. However, in the late nineteenth and early twentieth centuries, the question of whether stars are gaseous or liquid was the subject of much debate. P.-M. Robitaille provides a detailed discussion of this debate in his work [2, 3]. Recent evidence for liquid stars, in particular the extensive research performed by P.-M. Robitaille on the liquid metallic hydrogen model of the Sun, and his proposed liquid plasma model of the Sun [4], have re-opened the question.

In this book, the authors provide a novel general relativistic theory of the internal constitution of liquid stars, using a mathematical formalism first introduced by Abraham Zelmanov for calculating physically observable quantities in a four-dimensional pseudo-Riemannian space, known as the theory of chronometric invariants. This mathematical formalism allows to calculate physically observable chronometric-invariant tensors of any rank, based on operators of projection onto the time line and the spatial section of the observer. The basic idea is that physically observable quantities obtained by an observer should be the result of a projection of four-dimensional quantities onto the time line and onto the spatial section of the observer.

In the book, a star is modelled as a sphere of incompressible liquid described by Schwarzschild's metric. However, unlike Schwarzschild's solution which requires that the metric be free of singularities, space-time singularities are considered in this model. The conditions for a spatial singularity, known as a space break, are derived.

For our Sun, a space break is found to be within the Asteroid belt. The theory thus also provides a model of the internal constitution of our solar system. It provides an explanation for the presence of the Asteroid belt, the general structure of the planets inside and outside that orbit, and the net emission of energy by the planet Jupiter.

There is another space break located within a star's field. As a result of their analysis, the authors propose a new classification of stars based on the location of the space breaking of a star's field with respect to its surface. This classification of stars results in three main types: regular stars (covering white dwarfs to super-giants) covered in Chapter 2, of which Wolf-Rayet stars are a subtype, neutron stars and pulsars, covered in Chapter 4 and collapsars (i.e. black holes), covered in Chapter 5. Chapter 3 examines the properties of the stellar wind within their liquid star model.

The stellar mass-luminosity relation, which is the main empirical relation of observational astrophysics, is compared by the authors to that derived in the framework of the liquid model. From this they obtain the physical characteristics of the mechanism that produces energy inside the stars. Using the liquid model, the pressure inside stars can be calculated as a function of radius, including the central pressure. As pointed out by the authors, the temperature of the incompressible liquid star does not depend on pressure, only on the source of stellar energy. The authors match the calculated energy production of the suggested mechanism of thermonuclear fusion of the light atomic nuclei in the Hilbert core (the "inner sun") of the stars to the empirical mass-luminosity relation of observational astrophysics, to determine the density of the liquid stellar substance in the Hilbert core.

In the general relativistic model of liquid stars, the inside of the star is homogeneous, with a small core (about a few kilometres in radius) in its centre. The core is separated from the main mass of the star by the model's collapse surface with the radius depending on the star's mass. Despite almost all the mass of the star being located outside the core (the core is not a black hole), the force of gravity approaches to infinity on the surface of the core due to the inner space breaking of the star's field within it. The super-strong force of gravity is sufficient for the transfer of the necessary kinetic energy to the lightweight atomic nuclei of the stellar substance, to sustain the process of thermonuclear fusion. Thus, thermonuclear fusion of the light atomic nuclei is possible in the Hilbert core of each star. The energy produced by the thermonuclear fusion is the energy emitted by the stars: the small core of each star is its luminous "inner sun", while the generated stellar energy is transferred to the physical surface of the star by thermal conductivity. Due to the fact that the star's substance is liquid, more and more "nuclear fuel" is delivered from other regions of the star to its luminous Hilbert core, thus supporting the combustion inside the "nuclear boiler", until the time when all the nuclear fuel of the star is spent.

Pulsars and neutron stars are found to be stars whose physical radius is close to the radius of their Hilbert core. They are modelled by introducing an electromagnetic field in the theory to account for their rotation and gravitation. Electromagnetic radiation is found to be emitted only from the poles of those stars, along the axis of rotation of the stars.

Finally, the properties of black holes as derived from the model are considered. The authors find that regular stars cannot collapse. They derive the conditions for pulsars and neutron stars to become collapsars. Interestingly, the authors apply their model to the Universe and, based on their results, suggest that the Universe can be considered as a sphere of perfect liquid which is in a state of gravitational collapse (the liquid model of the Universe). Hence they deduce that the observable Universe is a collapsar, a huge black hole.

This book represents a solid contribution to our understanding of stellar structure from a general relativistic perspective. It provides a general relativistic underpinning to the theory of liquid stars. It raises new ideas on the constitution of stars and planetary systems, and proposes a new approach to stellar structure and stellar energy generation which is bound to generate much new research, and help us better understand stellar astrophysics.

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## References

1. Borissova L. and Rabounski D. Inside Stars. American Research Press, Rehoboth (NM, USA), 2013 (available from Progress in Physics website).
2. Robitaille P.-M. A Thermodynamic History of the Solar Constitution — I: The Journey to a Gaseous Sun, *Progress in Physics*, 2011, v. 7(3), pp. 3–25.
3. Robitaille P.-M. A Thermodynamic History of the Solar Constitution — II: The Theory of a Gaseous Sun and Jeans' Failed Liquid Alternative, *Progress in Physics*, 2011, v. 7(3), pp. 41–59.
4. Robitaille P.-M. A High Temperature Liquid PLasma Model of the Sun, *Progress in Physics*, 2007, v. 3(1), pp. 70–81.