DYNAMICS OF A THIN SPHERICALLY SYMMETRIC RADIATING SHELLS AND COLLAPSED ASTRONOMICAL OBJECTS

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A general relativistic model is used to investigate an X-ray bursters. The classical limit is found, and the magnitudes of the velocity and mass needed to detect relativistic effects are computed.

In ref. [1] it studied the dynamics of a thin dust radiating shell, endowed with spherical symmetry moving in the gravitational field of a central body. We used the General Relativity Theory; in our formalism the shell is a three-dimensional (two space like dimensions, one time like dimension) singular hypersurface [1, 2], with a Schwarzschild metric inside and Vaidya [3] metric outside.

We used the model to study the detection of relativistic effects in novae and supernovae, and reach to the conclusion that, using these astronomical objects General Relativity effect will be very difficult to detect. In ref. [3] Hamity and Spinosa considering also a Vaidya metric in the interior of the shell, used this new model to study planetary nebula.

In the present work we have used this last model to study different astronomical object: X-ray bursters, and Gamma-ray bursters.

The equation of motion

Hamity and Spinosa found the following equations of motion of the shell, where the case $L^-=0$ has been previously studied by Castagnino and Umérez [1], and L^- = constant has been studied by Castagnino and Aquilano [4]; these equations are:

$$R(A-B)=m_o$$

$$m_o \ddot{R}=-A\frac{m_o^2}{2R^2} - \frac{m^- m_o}{R^2} - AL^+ + BL^-$$

where m^- is the mass of central body, m^+ is the mass of the shell plus the mass of the central body $(m + m^-)$, R is the radious of the shell, m_o is the total energy of eject matter, L^- is the luminosity of the central star at the time of the explosion, L^+ is the shell luminosity, and

$$A=(\dot{R}^2 - \frac{2m^-}{R} + 1)^{1/2} \quad , \quad B=(\dot{R}^2 - \frac{2m^+}{R} + 1)^{1/2}$$

If low velocities are assumed, i.e., $\dot{R} \ll 1$ the newtonian approximation of this problem will be reached, thus if $m^- \ll R$, and $m^+ \ll R$ we obtain

$$A= 1 + \frac{1}{2} (\dot{R}^2 - \frac{2m^-}{R}) + \text{order } (\dot{R}^2 - \frac{2m^-}{R})^2$$

$$B= 1 + \frac{1}{2} (\dot{R}^2 - \frac{2m^+}{R}) + \text{order } (\dot{R}^2 - \frac{2m^+}{R})^2$$

then,

$$A-B= \frac{m}{R} + \text{order } (\dot{R}^2 - \frac{2m^{\pm}}{R})$$

where $m=m^+ - m^-$
and may be interpreted as the gravitational mass of the shell.

Also, we have,

$$A-B= \frac{m_o}{R}$$

Hence may be used to write,

$$m_o \cong m + \text{order } (\dot{R}^2 - \frac{2m^{\pm}}{R})^2$$

therefore gravitational mass approaches to proper mass, which is consistent with the assumption that this aproximation is a newtonian one. Thus from last equations we obtain,

$$m_o \ddot{R} = - \frac{m_o^2}{2R^2} - \frac{\bar{m} m_o}{R^2} - L^+ - L^-$$

This is the equation that would have been obtained if the evolution of this systems had been treated within the framework of newtonian theory, using m_o as the classical rest mass of the shell. Its interpretation is: the first term of the righthand side is the selfgravity force of a shell with mass m_o and radious R, while the second is the interaction force between such a shell and a spherically concentric body with mass m^-. The third term is the momentum transferred to the shell per unit time by the radiation emitted by the shell ifself, and the fourth term is the momentum transferred to the shell per unit time by the radiation emitted by the central body and absorbed at the interior surface of the shell.

Conclusion

In the previous paper [1], we reached to the conclusion that the General Relativity effects will be very difficult to detect, because the mass density is smaller in ordinary novae and supernovae; in the X-ray bursters and Gamma-ray burster, with the existence of neutron stars, we shown that it could not be possible to detect a General Relativity effect, using our formalism.

References

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