Intensive Energy of Gravitational Waves

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Abstract: ***Gravitation is the continuous outcome of energy and it also relates with the intensive energy of gravitational waves. Hernquist model has the advantage that it better represents the observed properties of elliptical galaxies. It leads completely analytical expressions for gravitational intensive energy of penetrating spherical galaxies.***

Keywords: Intensive energy, Gravitational waves, spherical galaxies, elliptical galaxies.

1. Introduction

With the discovery of pulsars, quasars, and galactic X-ray sources in the late 60’s early 70’s and the coincident expansion in the search of gravitational waves, relativistic gravity assumed an important place in the astro-physics of localized objects. Only by pushing Einstein’s solar system , tested general theory of relativity to the study of the extremes of gravitational collapse and its outcome did it seem that one could explain these frontier astronomical phenomena. The conclusion continues to be true today.

It is classic point of view, which goes back to the fifties that the Riemann tensor plays the main role in the definition of gravitational radiation in the exact theory. In this framework, most of the definition which appeared actually singled out classes of algebraically special Weltensors, in particular, Petrov type N is included in all of them. Another reason for studying a type N field is that such a type represents the dominant term of the Riemann tensor at large distance from an arbitrary isolated system.

Moreover, different field with algebraic properties similar to N- type appear also in the theory of gravitational wave and shock wave fronts. Lichnerowicz first studies the properties shared by such tensor field called singular double 2- forms. When the Riemann tensor is a singular double 2- form be defined it a “pure total radiation “field. Moreover, the Ricci tensor is null, then a pure total radiation field is of Peteov type N, and it is called a “pure gravitational field “. Actually the singular double 2- forms which appear in the theory of gravitational wave and shock front also share some differential properties with a pure gravitational radiation field, which allows our general definition of gravitational waves to cover all of these cases.

For a generic Einstein space time, following an analogy with the theory of electromagnetism, Bel introduced gravitational super energy, which in the weak field approximation, satisfy an energy flux theorem. He proposed defining gravitational radiation with the condition that the gravitational pollinating vector is not null; a pure gravitational radiation field has this property. Here the results by Lichonerowicz and Bel are revisited under a generic observer’s point of view and applied to the gravitational wave.

Finally, in the case of pure radiation of integral type, we attempt to investigate the physical meaning of the evolution laws for Lichonerowicz’s scalar and Bel’s super energy density W (u) in terms of mean values on a spatial domain. In the same context, we define an alternative super energy scalar, denoted by E (u), by which it seems possible to recover the usual concept of wave as energy transmission.

2. Sources of Gravitational Waves

In general terms, gravitational waves are radiated by objects whose motion involves acceleration, provided that the motion is not perfectly spherically symmetric (like an expanding or contracting sphere) or cylindrically symmetric (like a spinning disk or sphere). A simple example of this principle is provided by the spinning dumbbell. If the dumbbell spins like wheels on an axle, it will not radiate gravitational waves; if it tumbles end over end like two planets orbiting each other, it will radiate gravitational waves. The heavier the dumbbell and the faster it tumbles, the greater is the gravitational radiation it will give off. If we imagine an extreme case in which the two weights of the dumbbell are massive stars like neutron stars or black holes, orbiting each other quickly, then significant amounts of gravitational radiation would be given of

Some more detailed examples:

- Two objects orbiting each other in a quasi-Keplerian planar orbit (basically, as a planet would radiate.
- A supernova will radiate except in the unlikely event that the explosion is perfectly symmetric.
- An isolated non-spinning solid object moving at a constant speed will not radiate. This can be regarded as a consequence of the principle of conservation of linear momentum.
- A spinning disk will not radiate. This can be regarded as a consequence of the principle of conservation of angular momentum. However, it will show gravitomagnetic effects.
- A spherically pulsating spherical star (non-zero monopole moment or mass, but zero quadrupole moment) will not radiate, in agreement with Birkhoff's theorem.

More technically, the third time derivative of the quadrupole moment (or the l-th time derivative of the l-th multiple moment) of an isolated system's stress-energy tensor must be nonzero in order for it to emit gravitational radiation. This is analogous to the changing dipole moment of charge or current necessary for electromagnetic radiation

- Orbit the Sun) will radiate.

- A spinning non-axisymmetric planetoid — say with a large bump or dimple on the equator

3. Reference Frames and Gravitational Force

Let V_4 be the space time of general relativity oriented differentiable manifolds of dimension 4, provided with a strictly hyperbolic metric of sign +++. The class of the manifold and of the metric will be specified later when necessary. Let V_4 be an open connected subset with compact closure. Units are chosen in order to have the speed of light in empty c≥1. We call a reference frame a time like unit vector field u∈=c. The covariant derivative of u_α can be decomposed in the following way, where W(u) is the spatial unit volume 3-form Ω(u) is the vorticity vector, Ω(u) is the expansion symmetric tensor and is the a(u) is the acceleration vector. These fields belong to the rest space of u ie they are perpendicular to u. Let us consider a free falling point particle and a reference frame u, on the word line of the particle, the proper mass m and unit speed U=-1 are defined. The gravitational action is hidden inside this differential d operator, which involves the metric connection. To render it explicit, we have to introduce a generic reference frame u with the same orientation of U (u,U<0). We then have the following decomposition.

U=γ(U,u){u+δ(U,u)} --------------------------- (3.1)
P = p(U,u)+ δ(U,u)u) --------------------------- (3.2)

Where γ(U,u) is the relative velocity of U with respect to u, necessarily have V_2<1; γ(U, u)= - δ(U,u) is the Lorentz factor. δ(U,u) = γ(U, u) m is the relative energy, p(U,u)= δ(U,u) is the relative momentum. The vector fields above depend on the pair (U,u) and belong to the local rest space of u.

If V(u) & C'(Ω) is a generic vector field of local rest space of u(V(u).u=0), the relative standard Fermi-Walder time derivative, defined on the word line of the particle, is clearly, replacing the FW derivative with another differential operator would lead to a different gravitational force. It is believed that different observer's evolve their spatial frame along the lines of u by different transport laws, thus giving rise to different time derivatives other than FW. Relative derivative and anti-rotating FW gravitational forces differ by a different coefficient and are all equivalent for the aim of this paper, since the meaningful term, is invariant, and α_(n) of the Hernquist model are connected by the relation α_n=0.556α_p and α_p=1.77α_n.

The self gravitational potential energy of a poly tropic model is given by Dr. Chandrasekhar in 1939. |Ω|=(3GM^2)/(5-n)R) $|\Omega| = \frac{3GM^2}{5-n)R}$.............................. (3.3)
Equating Ω and M as given by (3.3) we get when=4, R=18 and α_n =0.056R.

Hernquist model has the advantage that it better represents the observed properties of elliptical galaxies. It leads to simple and completely analytical expressions for gravitational potential energy of penetrating spherical galaxies. To our knowledge, such simple, exact analytical expressions for these were not obtained earlier for spherical model of galaxies. W(r) obtained from Hernquist model closely agrees with those obtained from Plummer and poly tropic model for galaxies of the same mass and dynamical radius.

Table 3.4

α12	H(α12)	R12(0)/α12
1	0.3333	3
1.5	0.4032	3.72
2	0.4548	4.398
5	0.6176	8.096

4. Energy, Momentum and Angular Momentum

Waves familiar from other areas of physics such as water waves, sound waves, and electromagnetic waves are able to carry energy, momentum, and angular momentum. By carrying these away from a source, waves are able to rob that source of its energy, linear or angular momentum. Gravitational waves perform the same function. Thus, for example, a binary system loses angular momentum as the two orbiting objects spiral towards each other—the angular momentum is radiated away by gravitational waves.

The waves can also carry off linear momentum, a possibility that has some interesting implications for astrophysics. After two super massive black holes coalesce, emission of linear momentum can produce a "kick" with amplitude as large as 4000 km/s. This is fast enough to eject the coalesced black hole completely from its host galaxy. Even if the kick is too small to eject the black hole completely, it can remove it temporarily from the nucleus of the galaxy, after which it will oscillate about the center, eventually coming to rest.[15] A kicked black hole can also carry a star cluster with it, forming a hyper-compact stellar system.[16] Or it may carry gas, allowing the recoiling black hole to appear temporarily as a "naked quasar". The quasar SDSS J092712.65+294344.0 is believed to contain a recoiling super massive black hole Einstein@Home. Main article: Einstein@Home

In some sense, the easiest signals to detect should be constant sources. Supernovae and neutron star or black hole mergers should have larger amplitudes and be more interesting, but the waves generated will be more complicated. The waves given off by a spinning, a spherical neutron star would be "monochromatic"—like a pure tone in acoustics. It would not change very much in amplitude or frequency.

The Einstein@Home project is a distributed computing project similar to SETI@home intended to detect this type of simple gravitational wave. By taking data from LIGO and GEO, and sending it out in little pieces to thousands of volunteers for parallel analysis on their home computers, Einstein@Home can sift through the data far more quickly than would be possible otherwise

5. Conclusions

Analytical studies of galactic collisions and numerical stimulations of encounter between galaxies, a number of workers have either used the Plummer model or poly tropic model to represent galaxies. We therefore compare the results of the present analysis with those obtained for galaxies represented by these models. The density distribution of the Plummer model is given by

$\rho(r)=3M/4\pi\ \alpha_p^2\ \sqrt{(r^2\ )}+\alpha_p^2$ .... (5.1)

Where M is the total mass and α_p is the scale length. It follows that the mass interior and potential are given by

$M(r)=Mr^2/\sqrt{(r^2\ )}+\alpha_p^2$ ....(5.2)
$V(r)= GM/\sqrt{(r^2)}+\alpha_p^2$ ....(5.3)
$|\Omega| = 3\pi GM^2/32\alpha_p$ .... (5.4)

Hence, the dynamical radius $R=16\alpha_p/3\pi$ .... (5.5)

In table 2.4, we give the values of $H\ (\alpha_{12})$ and $R_{12}\ (0)/\alpha_2$ for a few values as obtained from the present analysis. Thus, the potential density pair of Hernquist model leads to a simple and completely analytical expression for the gravitational potential.

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Acknowledgements

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