Relatividade Geral,
Ondas Gravitacionais,
Objetos compactos,
Cosmologia,
Teorias alternativas,
etc

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Breve histórico

1990: Doutor pelo IAG/USP

2001: Livre-docência pelo IAG/USP

2002: Pesquisador Associado INPE (concurso público)*

2006: Pesquisador Titular INPE

Mais informações: CV Lattes

*1998 – 2002: Jovem Pesquisador FAPESP – INPE

Ponto de partida ....

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 8\pi T_{\mu\nu}$$

$$ds^2 = g_{\alpha\beta}\, dx^\alpha dx^\beta$$

$$T^{\alpha\beta} = (\rho + p)\, u^\alpha u^\beta + p\, g^{\alpha\beta}$$

Relatividade Geral

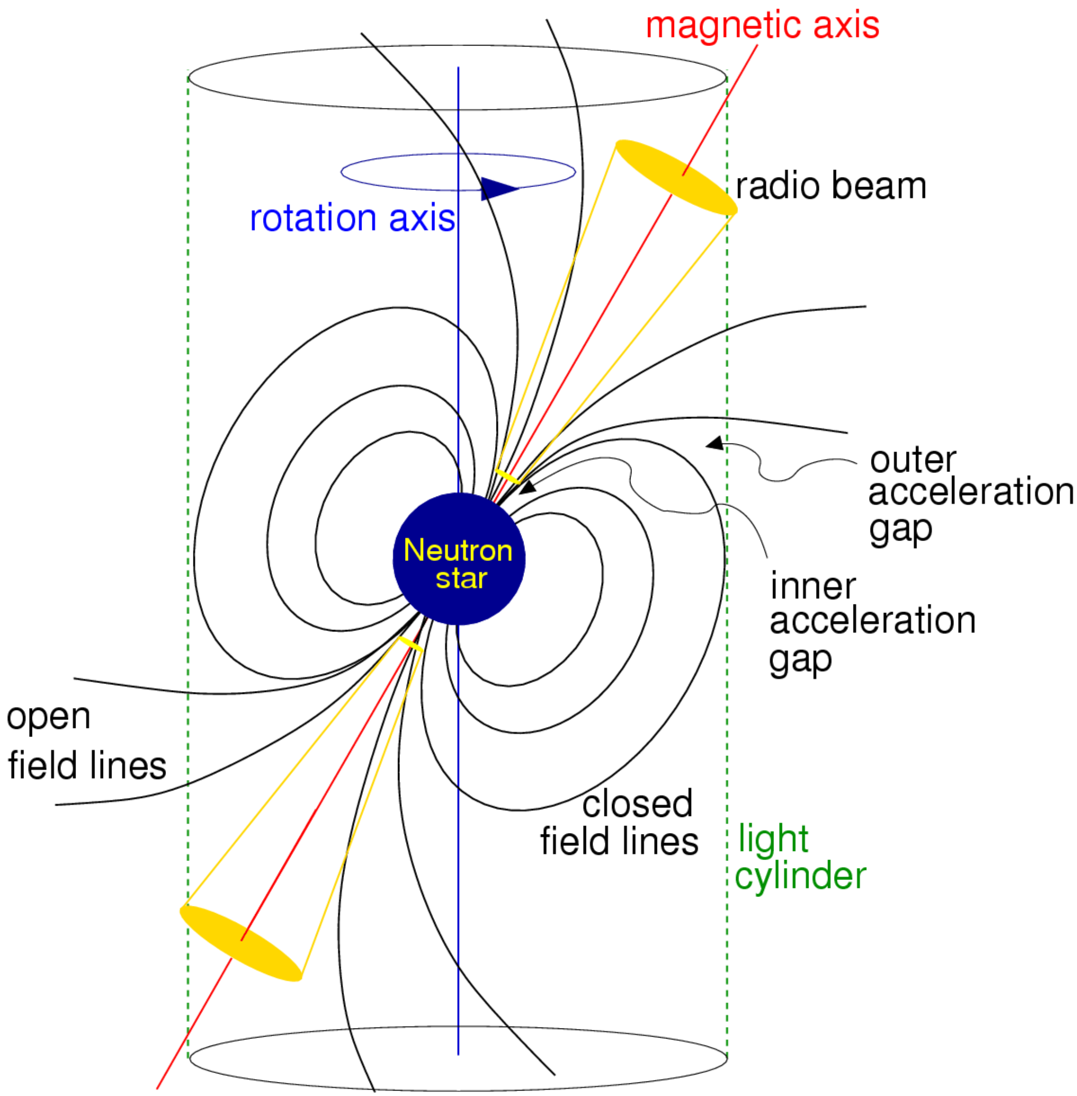
- Fontes de Ondas Gravitacionais
- Detecção de Ondas Gravitacionais
- Objetos compactos
- Relatividade Geral Algébrica e Numérica

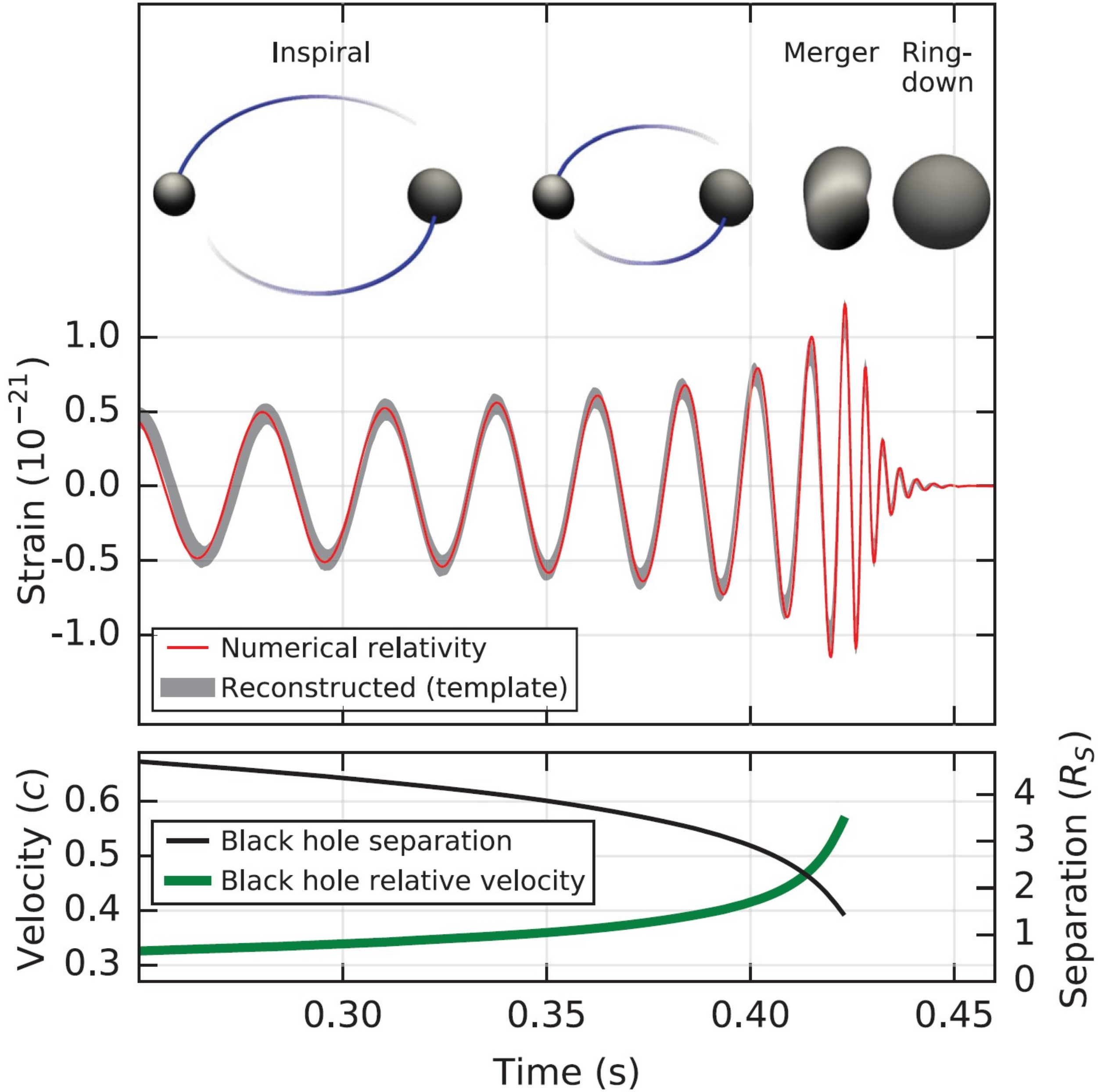
Teorias alternativas à Relatividade Geral

Algumas motivações:

- Expansão acelerada
- RG não é quantizável

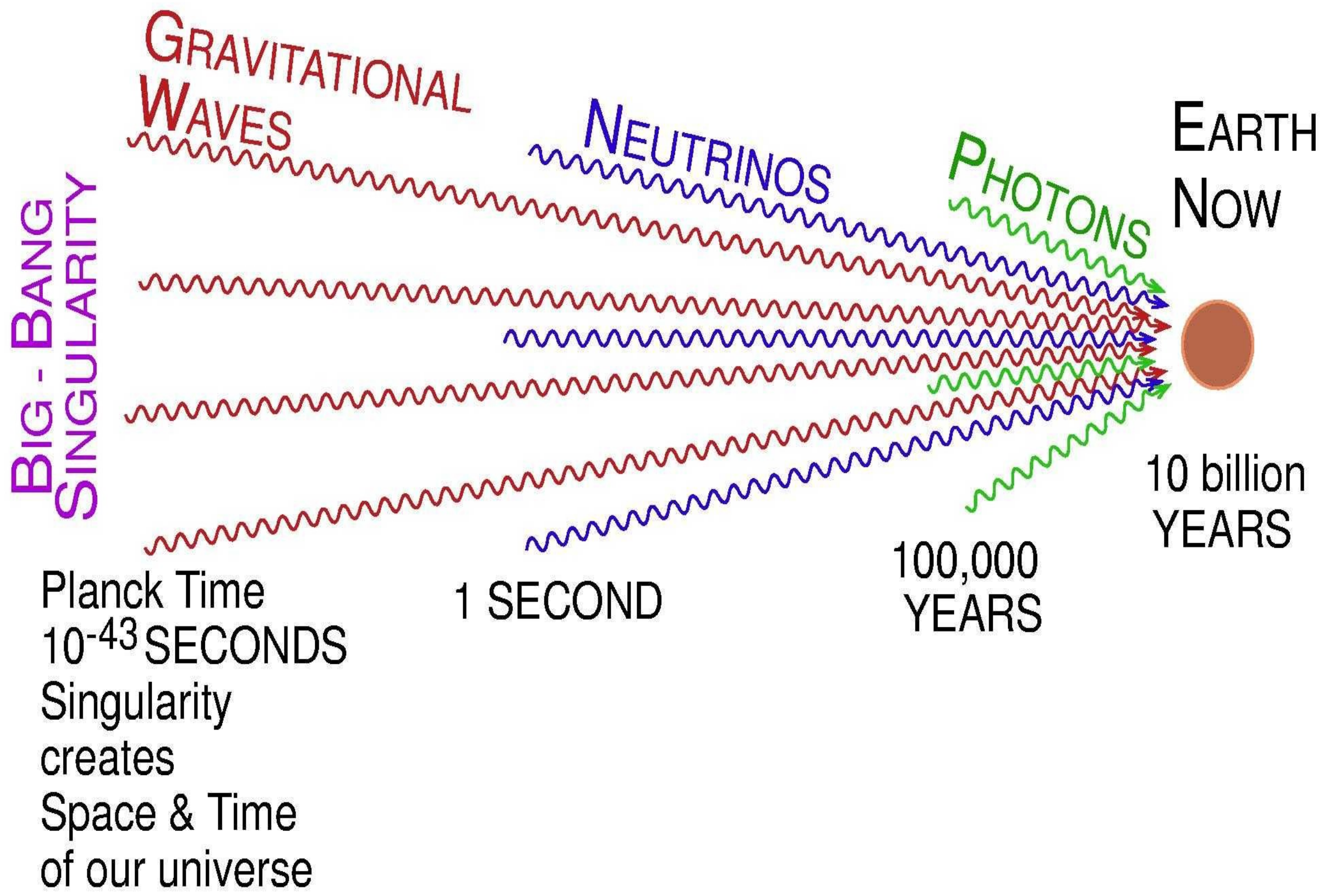
Fontes de Ondas Gravitacionais


magnetic axis
radio beam
rotation axis
outer acceleration gap
inner acceleration gap
Neutron star
open field lines
closed field lines
light cylinder

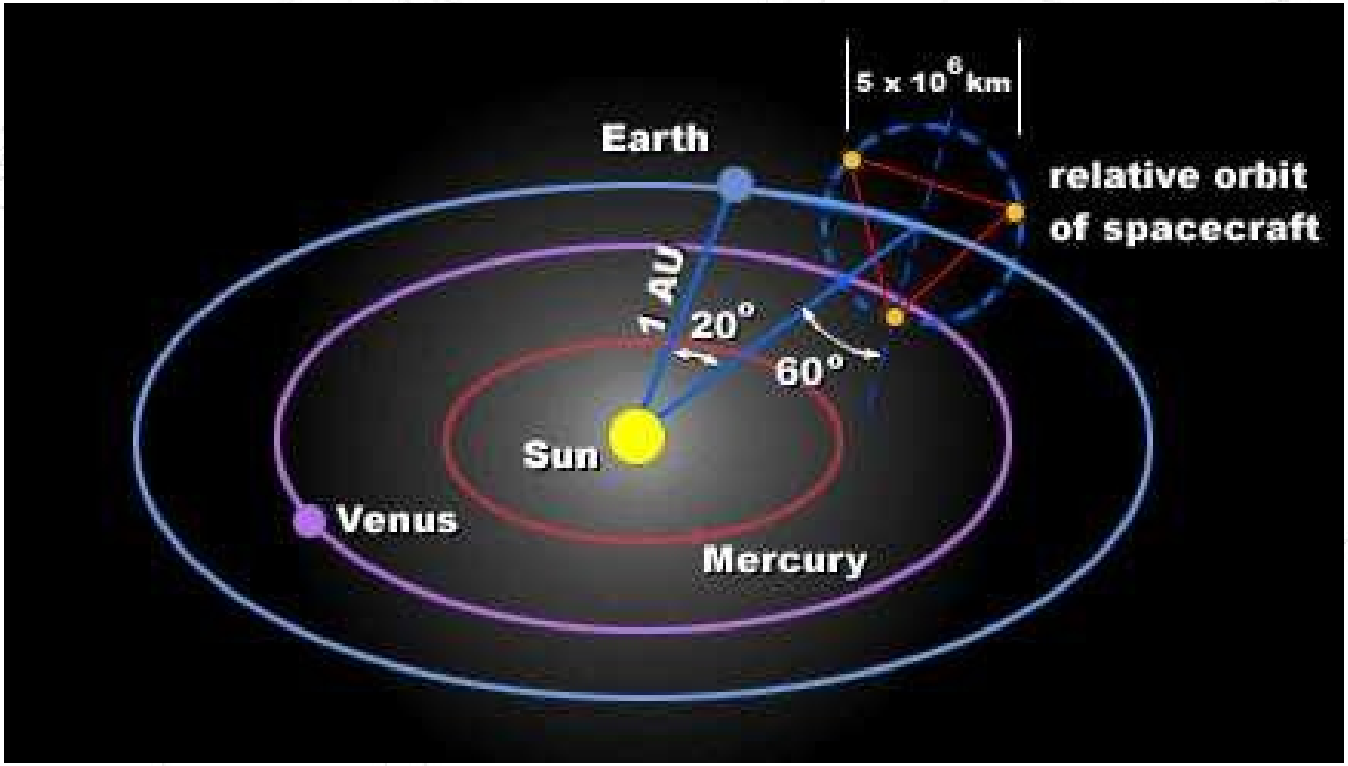


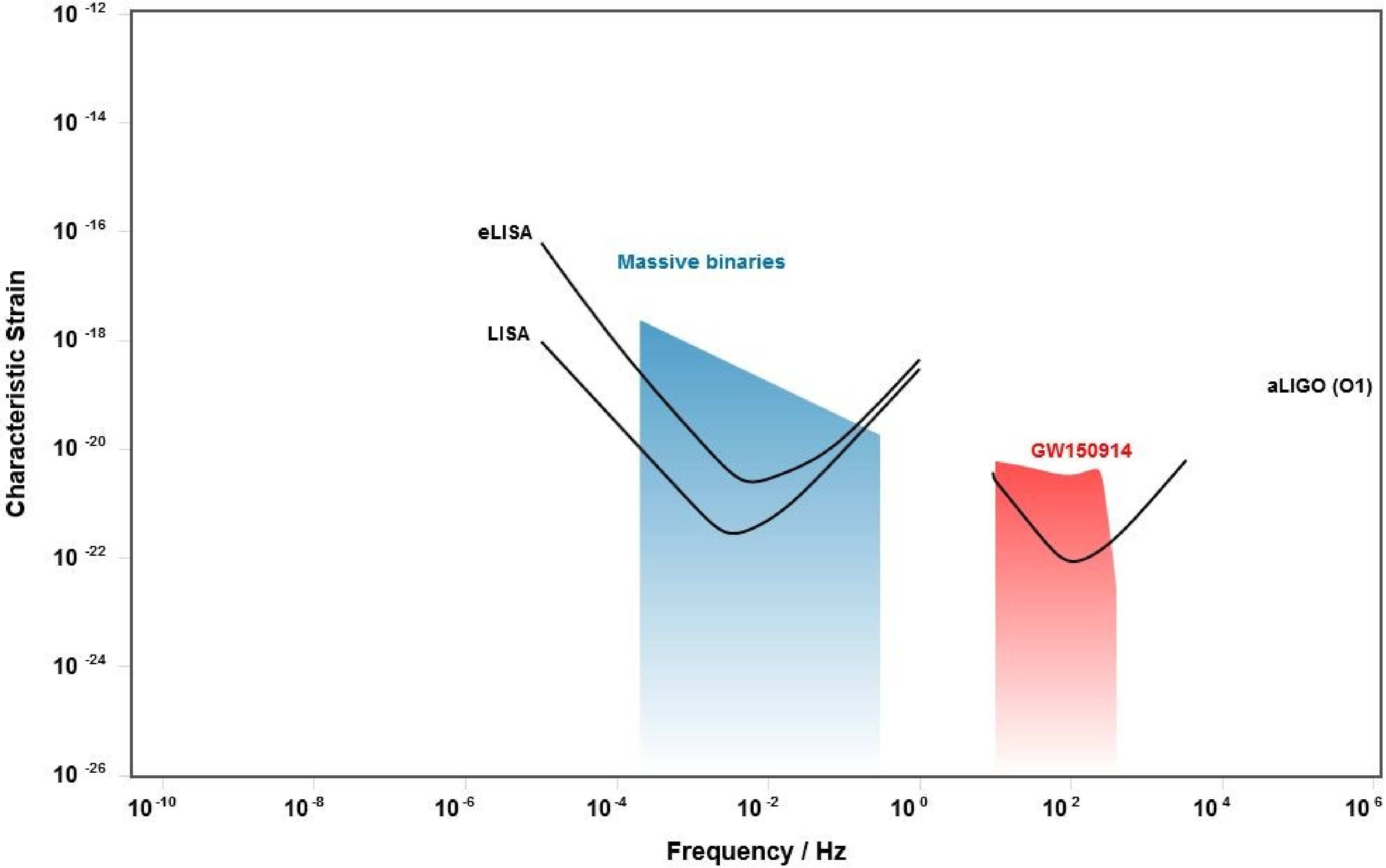
(http://journals.aps.org/prl/pdf/10.1103/PhysRevLett.116.061102)

- Big-Bang Birth of Universe



Detecção de Ondas Gravitacionais


5 x 10^6 km
Earth
relative orbit
of spacecraft
1 AU
20°
60°
Sun
Venus
Mercury



Characteristic Strain
10 -12
10 -14
10 -16
10 -18
10 -20
10 -22
10 -24
10 -26
eLISA
LISA
Massive binaries
GW150914
aLIGO (O1)
10 -10
10 -8
10 -6
10 -4
10 -2
10 0
10 2
10 4
10 6
Frequency / Hz

Artigos Publicados

IOP Publishing Classical and Quantum Gravity

Class. Quantum Grav. 33 (2016) 105010 (15pp) doi:10.1088/0264-9381/33/10/105010

Point particle binary system with components of different masses in the linear regime of the characteristic formulation of general relativity

C E Cedeño M and J C N de Araujo

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Published 19 April 2016

CrossMark

Abstract

A study of binary systems composed of two point particles with different masses in the linear regime of the characteristic formulation of general relativity with a Minkowski background is provided. The present paper generalizes a previous study by Bishop *et al*. The boundary conditions at the world tubes generated by the particles's orbits are explored, where the metric variables are decomposed in spin-weighted spherical harmonics. The power lost by the emission of gravitational waves is computed using the Bondi News function. The power found is the well-known result obtained by Peters and Mathews using a different approach. This agreement validates the approach considered here. Several multipole term contributions to the gravitational radiation field are also shown.

Gen Relativ Gravit (2016) 48:45
DOI 10.1007/s10714-016-2038-1

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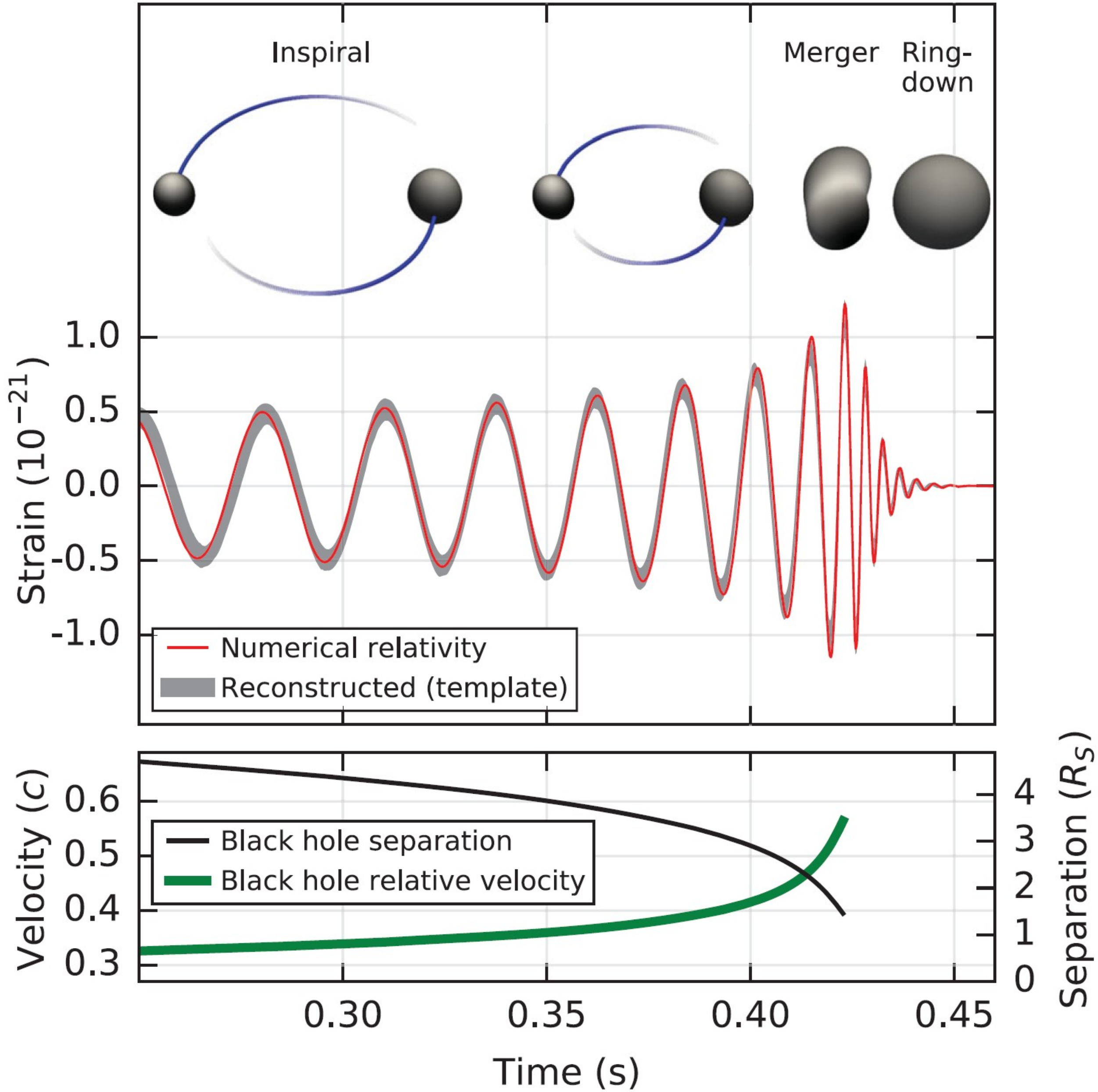
RESEARCH ARTICLE

Gravitational radiation by point particle eccentric binary systems in the linearised characteristic formulation of general relativity

C. E. Cedeño Montaña[1] · J. C. N. de Araujo[1]

Received: 1 October 2015 / Accepted: 3 March 2016

Abstract We study a binary system composed of point particles of unequal masses in eccentric orbits in the linear regime of the characteristic formulation of general relativity, generalising a previous study found in the literature in which a system of equal masses in circular orbits is considered. We also show that the boundary conditions on the time-like world tubes generated by the orbits of the particles can be extended beyond circular orbits. Concerning the power lost by the emission of gravitational waves, it is directly obtained from the Bondi's News function. It is worth stressing that our results are completely consistent, because we obtain the same result for the power derived by Peters and Mathews, in a different approach, in their seminal paper of 1963. In addition, the present study constitutes a powerful tool to construct extraction schemes in the characteristic formalism to obtain the gravitational radiation produced by binary systems during the inspiralling phase.



(http://journals.aps.org/prl/pdf/10.1103/PhysRevLett.116.061102)

The Astrophysical Journal, 823:97 (8pp), 2016 June 1 doi:10.3847/0004-637X/823/2/97

THE INFLUENCE OF QUANTUM VACUUM FRICTION ON PULSARS

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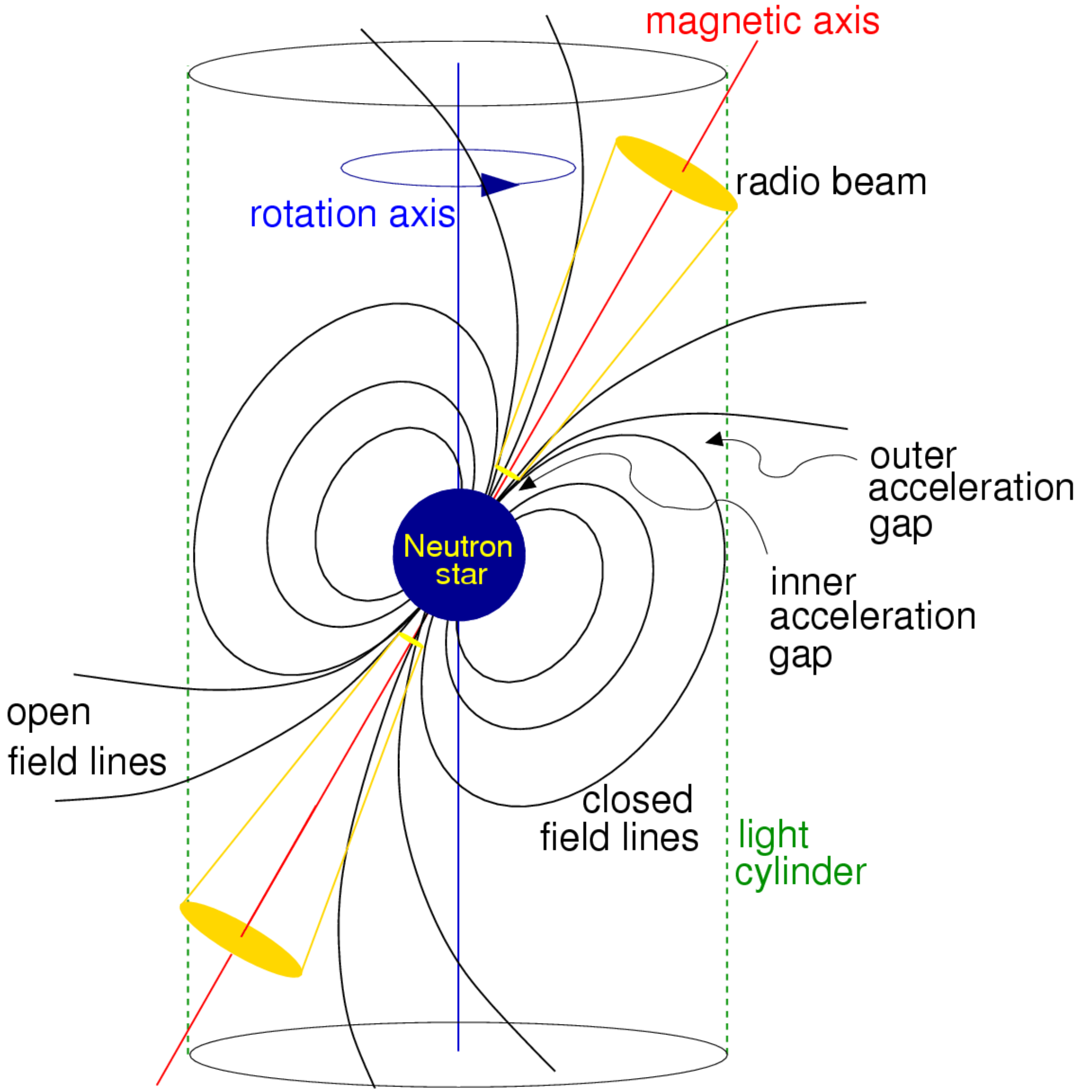
ABSTRACT

We first revisit the energy loss mechanism known as quantum vacuum friction (QVF), clarifying some of its subtleties. Then we investigate the observables that could easily differentiate QVF from the classical magnetic dipole radiation for pulsars with accurately measured braking indices (n). We show that this is particularly the case for the time evolution of a pulsar's magnetic dipole direction ($\dot{\phi}$) and surface magnetic field ($\dot{B}_0$). As is well known in the context of the classic magnetic dipole radiation, $n < 3$ would only be possible for positive ($\dot{B}_0/B_0 + \dot{\phi}/\tan\phi$), which, for instance, leads to $\dot{B}_0 > 0$ ($\dot{\phi} > 0$) when ϕ (B_0) is constant. On the other hand, we show that QVF can result in very different predictions with respect to those above. Finally, even if $\dot{B}_0$ has the same sign in both of the aforementioned models for a pulsar, then, for a given ϕ, we show that they give rise to different associated timescales, which could be another way to falsify QVF.


magnetic axis
radio beam
rotation axis
outer acceleration gap
inner acceleration gap
Neutron star
open field lines
closed field lines
light cylinder

Journal of Cosmology and Astroparticle Physics
An IOP and SISSA journal

Gravitational wave emission by the high braking index pulsar PSR J1640-4631

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Published July 15, 2016

Abstract. Recently, a braking index for the pulsar PSR J1640-4631 has been measured. With a braking index of $n = 3.15 \pm 0.03$, this pulsar has the highest braking index ever measured. As it is well known, a pure magnetic dipole brake yields $n = 3$, whereas a pure gravitational wave (GW) brake yields $n = 5$. Therefore, each of these mechanisms alone can not account for the braking index found for PSR J1640-4631. Here we consider in detail that such a braking index could be accounted for if the spindown model combines magnetic dipole and GW brakes. Then, we briefly discuss the detectability of this pulsar by aLIGO and the planned Einstein Telescope. In particular, we show that the amplitude of the GW that comes from our model is around a factor four lower than the amplitude modeled exclusively by GW energy loss. Another interesting outcome of our modeling is that it is possible to obtain the ellipticity from the braking index and other pulsar parameters.

JCAP07(2016)023

Eur. Phys. J. C (2016) 76:481
DOI 10.1140/epjc/s10052-016-4327-y

THE EUROPEAN PHYSICAL JOURNAL C

CrossMark

Regular Article - Theoretical Physics

Gravitational waves from pulsars with measured braking index

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Divisão de Astrofísica, Instituto Nacional de Pesquisas Espaciais, Avenida dos Astronautas 1758, São José dos Campos, SP 12227–010, Brazil

Received: 28 April 2016 / Accepted: 22 August 2016

Abstract We study the putative emission of gravitational waves (GWs) in particular for pulsars with measured braking index. We show that the appropriate combination of both GW emission and magnetic dipole brakes can naturally explain the measured braking index, when the surface magnetic field and the angle between the magnetic dipole and rotation axes are time dependent. Then we discuss the detectability of these very pulsars by aLIGO and the Einstein Telescope. We call attention to the realistic possibility that aLIGO can detect the GWs generated by at least some of these pulsars, such as Vela, for example.

The Astrophysical Journal, 831:35 (5pp), 2016 November 1
doi:10.3847/0004-637X/831/1/35

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GRAVITATIONAL WAVES FROM PULSARS AND THEIR BRAKING INDICES: THE ROLE OF A TIME DEPENDENT MAGNETIC ELLIPTICITY

José C. N. de Araujo, Jaziel G. Coelho, and César A. Costa
Divisão de Astrofísica, Instituto Nacional de Pesquisas Espaciais, Avenida dos Astronautas 1758, 12227–010 São José dos Campos, SP, Brazil; jcarlos.dearaujo@inpe.br, jaziel.coelho@inpe.br, cesar.costa@inpe.br
Received 2016 July 12; revised 2016 August 5; accepted 2016 August 8; published 2016 October 25

ABSTRACT

We study the role of time dependent magnetic ellipticities (ϵ_B) on the calculation of the braking index of pulsars. Moreover, we study the consequences of such a ϵ_B on the amplitude of gravitational waves (GWs) generated by pulsars with measured braking indices. We show that, since the ellipticity generated by the magnetic dipole is extremely small, the corresponding amplitude of GWs is much smaller than the amplitude obtained via the spindown limit.

PHYSICAL REVIEW D **94,** 081101(R) (2016)

Coherent observations of gravitational radiation with LISA and gLISA

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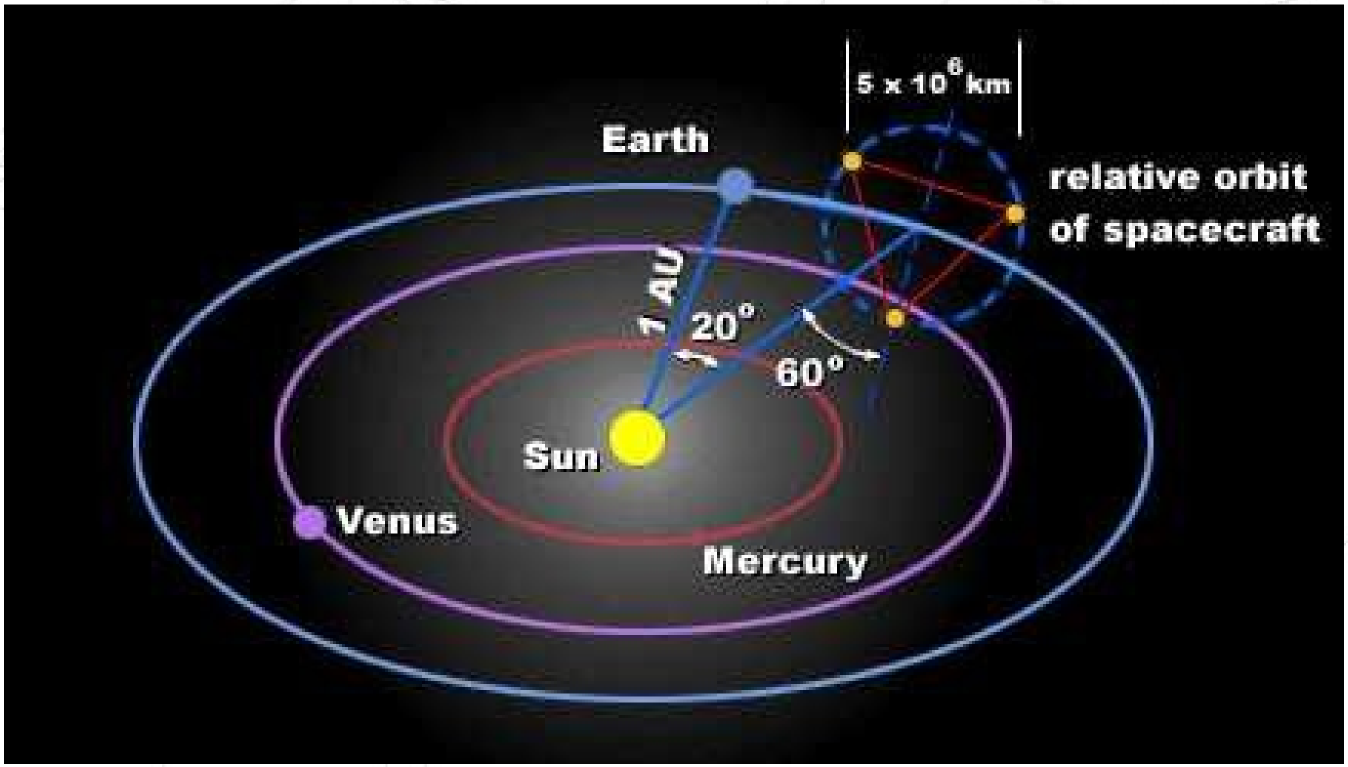
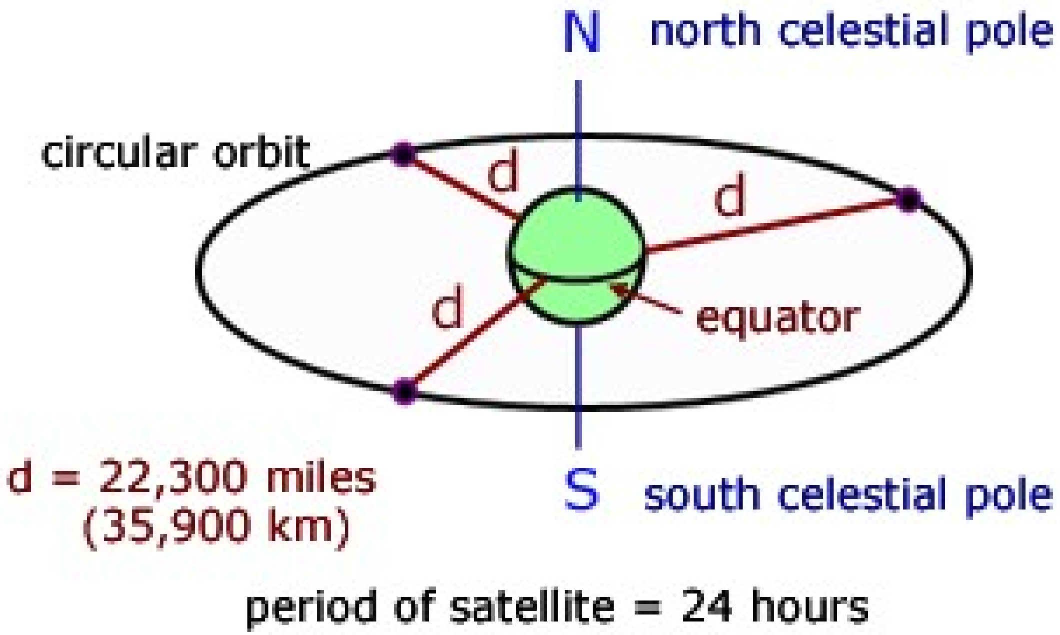
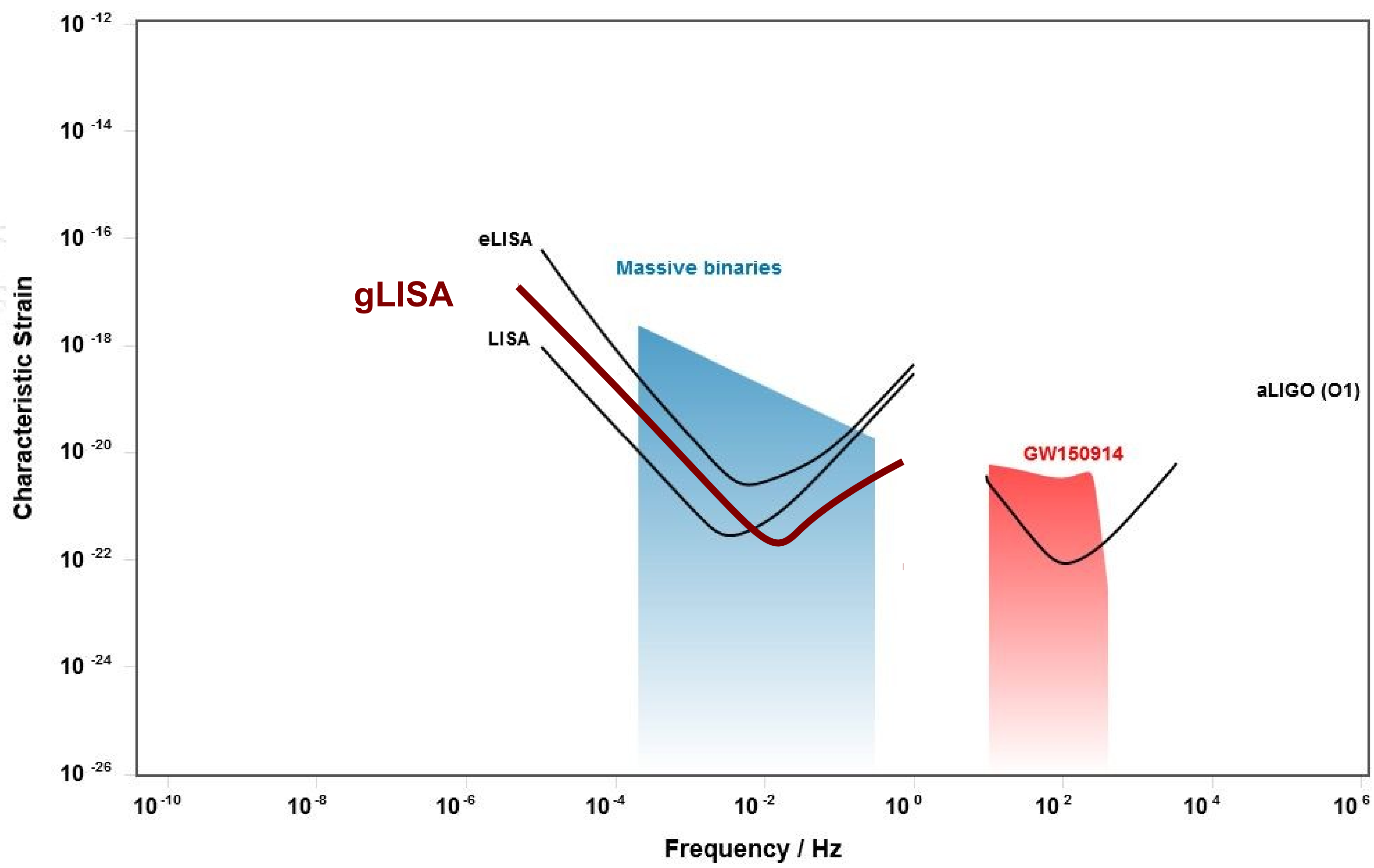
José C. N. de Araujo†
Divisão de Astrofísica, Instituto Nacional de Pesquisas Espaciais, Avenida dos Astronautas 1758,
São José dos Campos, São Paulo 12227-010, Brasil
(Received 15 August 2016; published 26 October 2016)

The geosynchronous Laser Interferometer Space Antenna (gLISA) is a space-based gravitational wave (GW) mission that, for the past 5 years, has been under joint study at the Jet Propulsion Laboratory; Stanford University; the National Institute for Space Research (I.N.P.E., Brazil); and Space Systems Loral. If flown at the same time as the LISA mission, the two arrays will deliver a joint sensitivity that accounts for the best performance of both missions in their respective parts of the millihertz band. This simultaneous operation will result in an optimally combined sensitivity curve that is "white" from about 3×10^{-3} Hz to 1 Hz, making the two antennas capable of detecting, with high signal-to-noise ratios (SNRs), coalescing black-hole binaries (BHBs) with masses in the range $(10 - 10^8) M_\odot$. Their ability of jointly tracking, with enhanced SNR, signals similar to that observed by the Advanced Laser Interferometer Gravitational Wave Observatory (aLIGO) on September 14, 2015 (the GW150914 event) will result in a larger number of observable small-mass binary black holes and an improved precision of the parameters characterizing these sources. Together, LISA, gLISA and aLIGO will cover, with good sensitivity, the $(10^{-4} - 10^3)$ Hz frequency band.



5 x 10^6 km
Earth
relative orbit
of spacecraft
1 AU
20°
60°
Sun
Venus
Mercury


N
north celestial pole
circular orbit
d
d
d
equator
S
south celestial pole
d = 22,300 miles
(35,900 km)
period of satellite = 24 hours

Characteristic Strain
10 -12
10 -14
10 -16
10 -18
10 -20
10 -22
10 -24
10 -26
eLISA
gLISA
LISA
Massive binaries
aLIGO (O1)
GW150914
10 -10
10 -8
10 -6
10 -4
10 -2
10 0
10 2
10 4
10 6
Frequency / Hz

PHYSICAL REVIEW D **94,** 024032 (2016)

Gravitational waves in $f(R,T)$ and $f(R,T^{\phi})$ theories of gravity

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(Received 5 May 2016; published 14 July 2016)

There is a host of alternative theories of gravitation in the literature, among them the $f(R,T)$ and $f(R,T^{\phi})$ theories recently elaborated by Harko *et al.* In these theories, R, T and T^{ϕ} are respectively the Ricci scalar and the traces of the energy-momentum tensors of matter and of a scalar field. There is already in the literature a series of studies of different forms of the $f(R,T)$ and $f(R,T^{\phi})$ functions as well as their cosmological consequences. However, there have been no studies so far related to gravitational waves. Here we consider such an issue, in particular, studying the putative extra polarization modes that can appear in the scope of such theories. Different functional forms of $f(R,T^{\phi})$ are considered and the gravitational waveforms are found for the extra polarization modes in the cases in which they are present.

Astroparticle Physics 87 (2017) 18–22

Contents lists available at ScienceDirect

Astroparticle Physics

journal homepage: www.elsevier.com/locate/astropartphys

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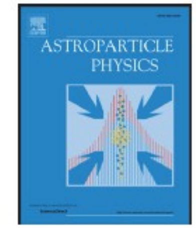

Primordial gravitational waves in running vacuum cosmologies

CrossMark

D.A. Tamayo [a], J.A.S. Lima [b], M.E.S. Alves [c], J.C.N. de Araujo [d,*]

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[b] Departamento de Astronomia, Universidade de São Paulo, Rua do Matão 1226, 05508-900, São Paulo, Brazil
[c] Instituto de Ciência e Tecnologia, Universidade Estadual Paulista, São José dos Campos, SP, 12247-016, Brazil
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ARTICLE INFO

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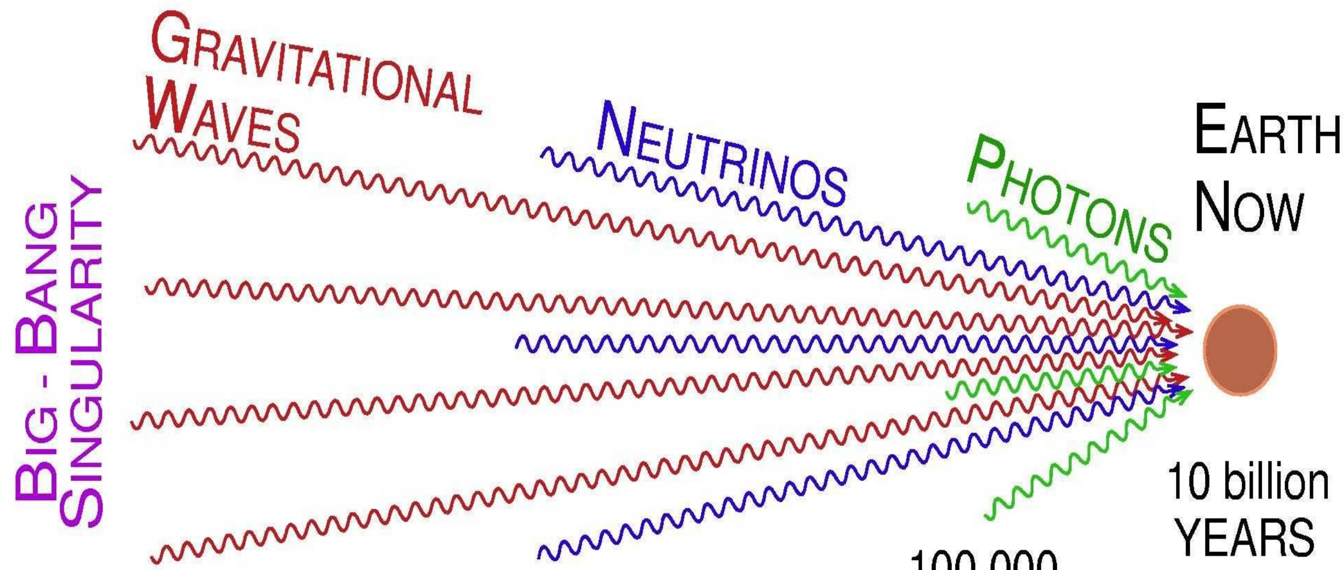
Wave generation and sources
Relativity and gravitation
Cosmology

ABSTRACT

We investigate the cosmological production of gravitational waves in a nonsingular flat cosmology powered by a "running vacuum" energy density described by $\rho_\Lambda \equiv \rho_\Lambda(H)$, a phenomenological expression potentially linked with the renormalization group approach in quantum field theory in curved space-times. The model can be interpreted as a particular case of the class recently discussed by Perico et al. (2013) [25] which is termed complete in the sense that the cosmic evolution occurs between two extreme de Sitter stages (early and late time de Sitter phases). The gravitational wave equation is derived and its time-dependent part numerically integrated since the primordial de Sitter stage. The generated spectrum of gravitons is also compared with the standard calculations where an abrupt transition, from the early de Sitter to the radiation phase, is usually assumed. It is found that the stochastic background of gravitons is very similar to the one predicted by the cosmic concordance model plus inflation except at higher frequencies ($\nu \gtrsim 100$ kHz). This remarkable signature of a "running vacuum" cosmology combined with the proposed high frequency gravitational wave detectors and measurements of the CMB polarization (B-modes) may provide a new window to confront more conventional models of inflation.

- Big-Bang Birth of Universe



Planck Time
10^{-43} SECONDS
Singularity
creates
Space & Time
of our universe

Trabalhos desenvolvidos e em desenvolvimento …

- Relatividade Geral Algébrica e Numérica na formulação 2+2 (ex-estudante: Carlos Eduardo)

- gLISA: uma alternativa ao (e)LISA (c/ Massimo Tinto e Márcio Alves)

Trabalhos desenvolvidos e em desenvolvimento …

- Pulsars: ondas gravitacionais e QVF (Jaziel)
- AE Aqr (c/ Cláudia et al)
- Fundos de ondas gravitacionais em cosmologias com decaimento do vácuo (Márcio Alves e José Ademir Lima)
- Fundos de Ondas Gravitacionais de origem cosmológica em teorias alternativas (Mariana (PhD) e Márcio Alves)
- Etc ….

FIM