Física além do Modelo Padrão em Dados Cosmológicos e Astrofísicos

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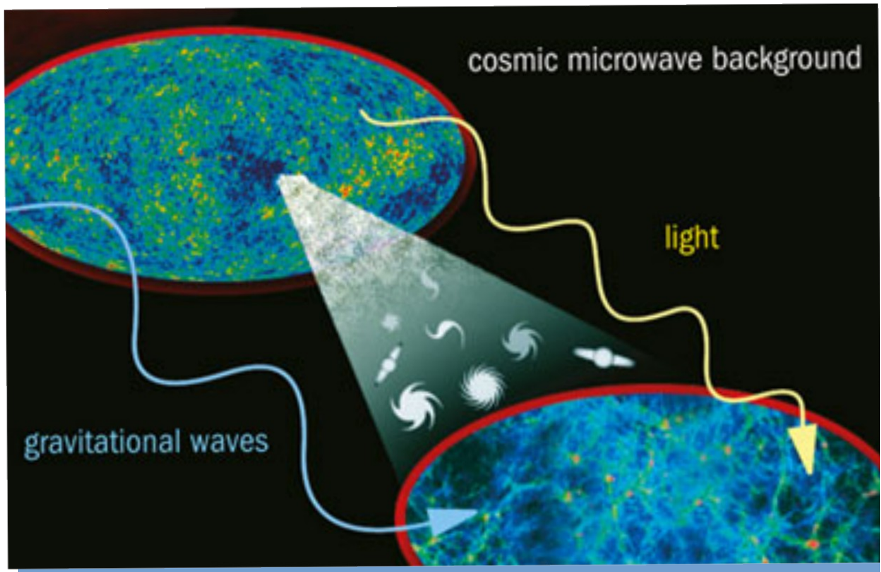
Workshop da Pós-Graduação em Astrofísica - 2019

Breve Apresentação e Resumo

- Postdoc e Docente Colaborador na Pós-Graduação INPE-Divisão de Astrofísica.

- Minhas principais linhas de pesquisa

  <u>Interface Teoria-Observação com</u> :



Energia Escura

Teorias Alternativas de Gravidade

Matéria Escura

Neutrinos

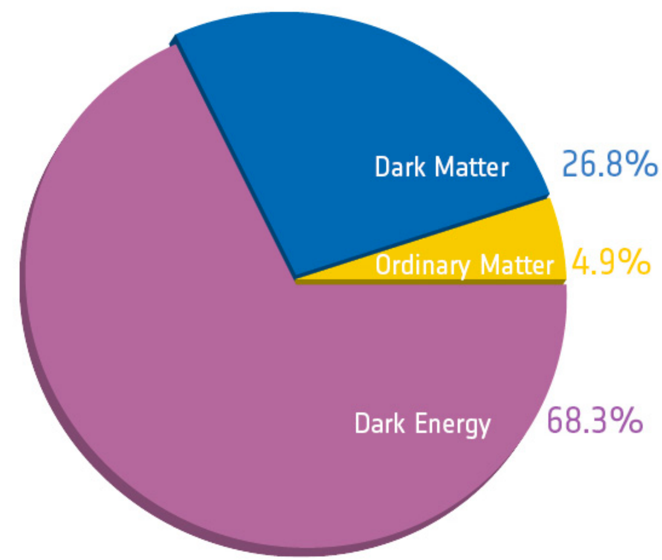
→

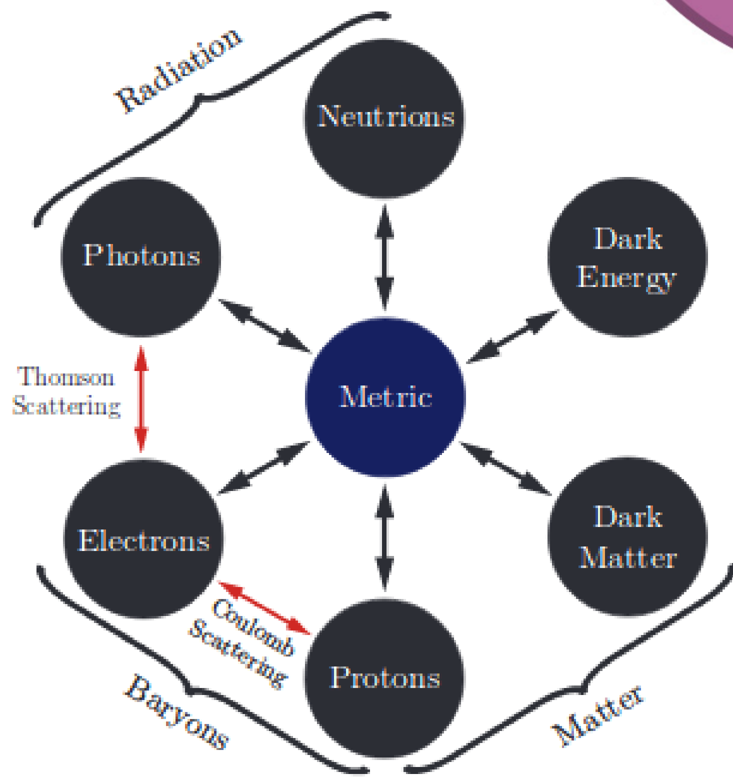
Radiação Cósmica de Fundo

Universo em Grande Escala

Ondas Gravitacionais

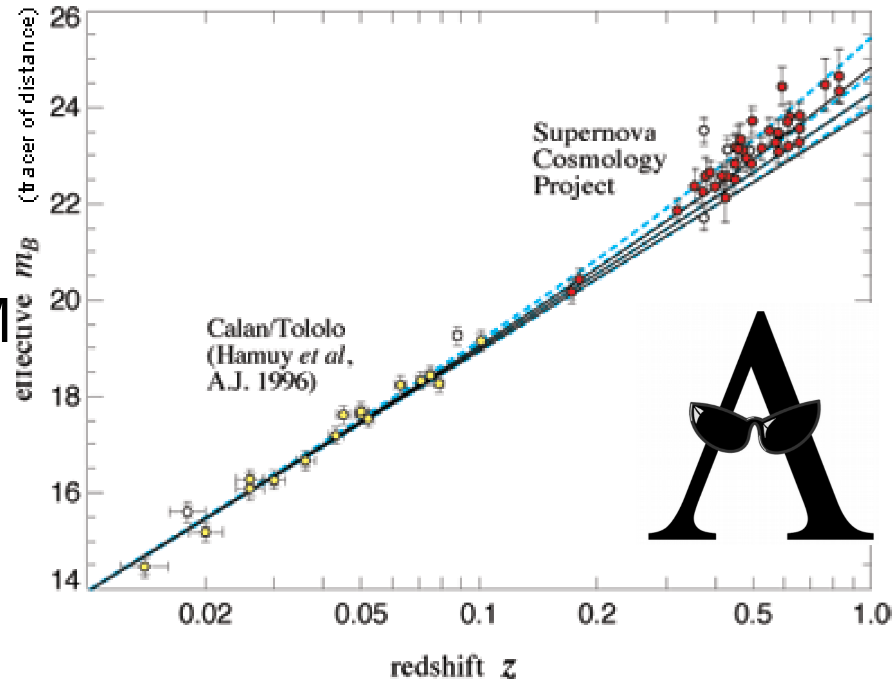
O que Significa uma Nova Física ?





Nossos problemas centrais ...

1 - Atual estágio de expansão acelerada do Universo



- Modelo mais simples: LambdaCDM
- Problemas teóricos com Lambda

- Alternativas ?

Alternativas ...

$$R_{ab} - \frac{1}{2} g_{ab} R + \Lambda g_{ab} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

Ricci curvature tensor (R_{ab})
the scalar curvature (R)
the metric tensor (g_{ab})
the cosmological constant (Λ)
Newton's gravitational constant (G)
the stress-energy tensor ($T_{\mu\nu}$)
the spatial region of mass-energy-Matter being measured as determined by the speed of Energy in vacuum (c^4)

f(R) gravity,
Scalar-tensor theory,
Braneworlds,
Gauss-Bonnet gravity,
Galileon gravity,
.....

Quintessence,
K-essence,
Chaplygin gas,
Coupled dark energy,
.....

Após 20 anos, LCDM **ainda é** o melhor que temos a nível observacional **em termos globais**. Nosso modelo de concordância cósmica. Várias evidências observacionais de modelos melhores que LCDM na literatura, mas nada conclusivo. Exemplo :

PHYSICAL REVIEW D **96,** 103511 (2017)

Echo of interactions in the dark sector

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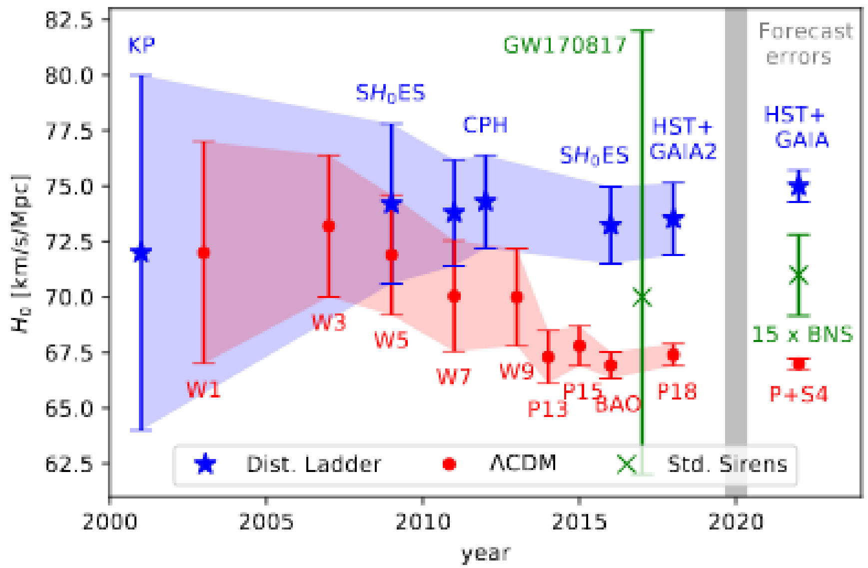
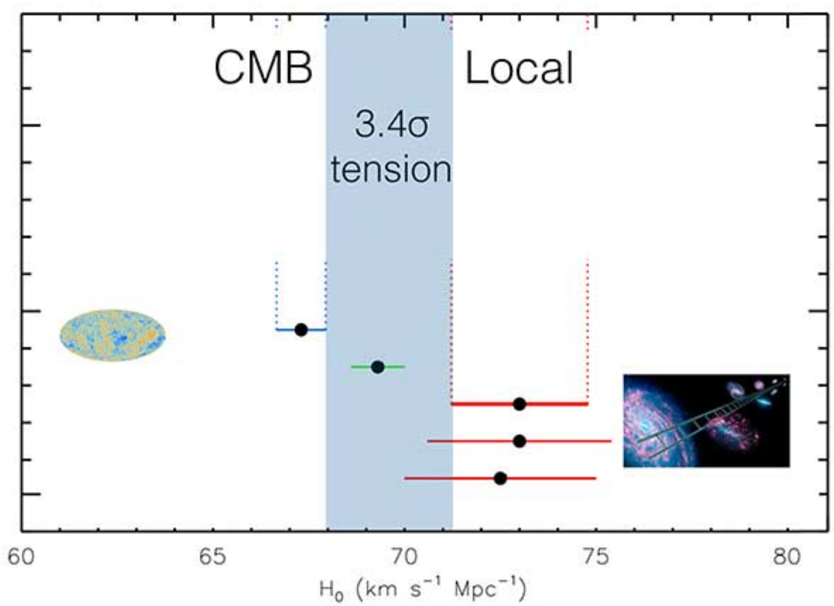
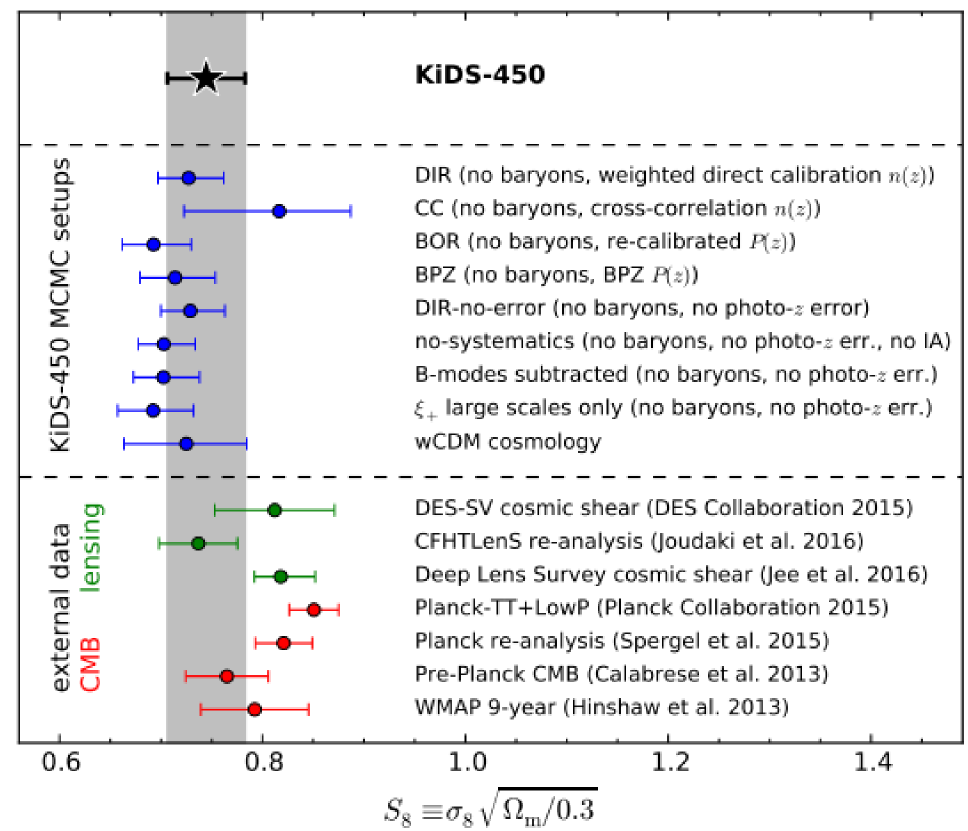
(Received 2 March 2017; published 13 November 2017)

Tensões em H0 e S8







Journal of Cosmology and Astroparticle Physics
An IOP and SISSA journal

Structure formation in $f(T)$ gravity and a solution for H_0 tension

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Dark sector interaction: a remedy of the tensions between CMB and LSS data

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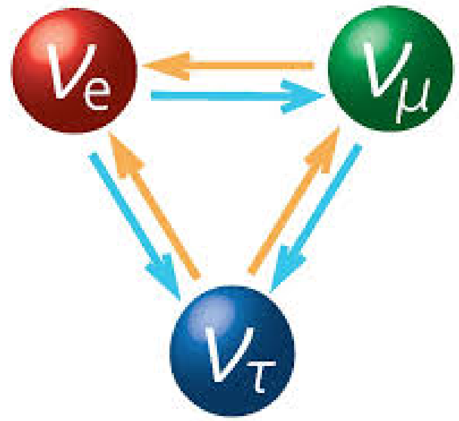
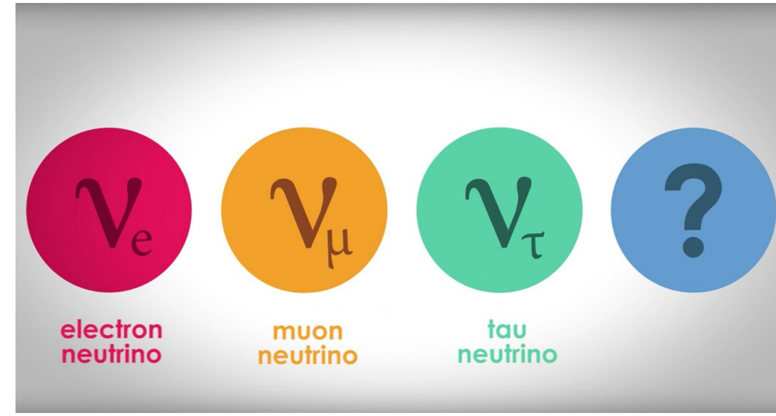
The well-known tensions on the cosmological parameters H_0 and σ_8 within the ΛCDM cosmology shown by the Planck-CMB and LSS data are possibly due to the systematics in the data or our ignorance of some new physics beyond the ΛCDM model. In this letter, we focus on the second possibility, and investigate a minimal extension of the ΛCDM model by allowing a coupling between its dark sector components (dark energy and dark matter). We analyze this scenario with Planck-CMB, KiDS and HST data, and find that the H_0 and σ_8 tensions disappear at 68% CL. In the joint analyzes with Planck, HST and KiDS data, we find non-zero coupling in the dark sector up to 99% CL. Thus, we find a strong statistical support from the observational data for an interaction in the dark sector of the Universe while solving the H_0 and σ_8 tensions simultaneously.





Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

MNRAS **473**, 4404–4409 (2018) doi:10.1093/mnras/stx2661

Probing the properties of relic neutrinos using the cosmic microwave background, the *Hubble Space Telescope* and galaxy clusters

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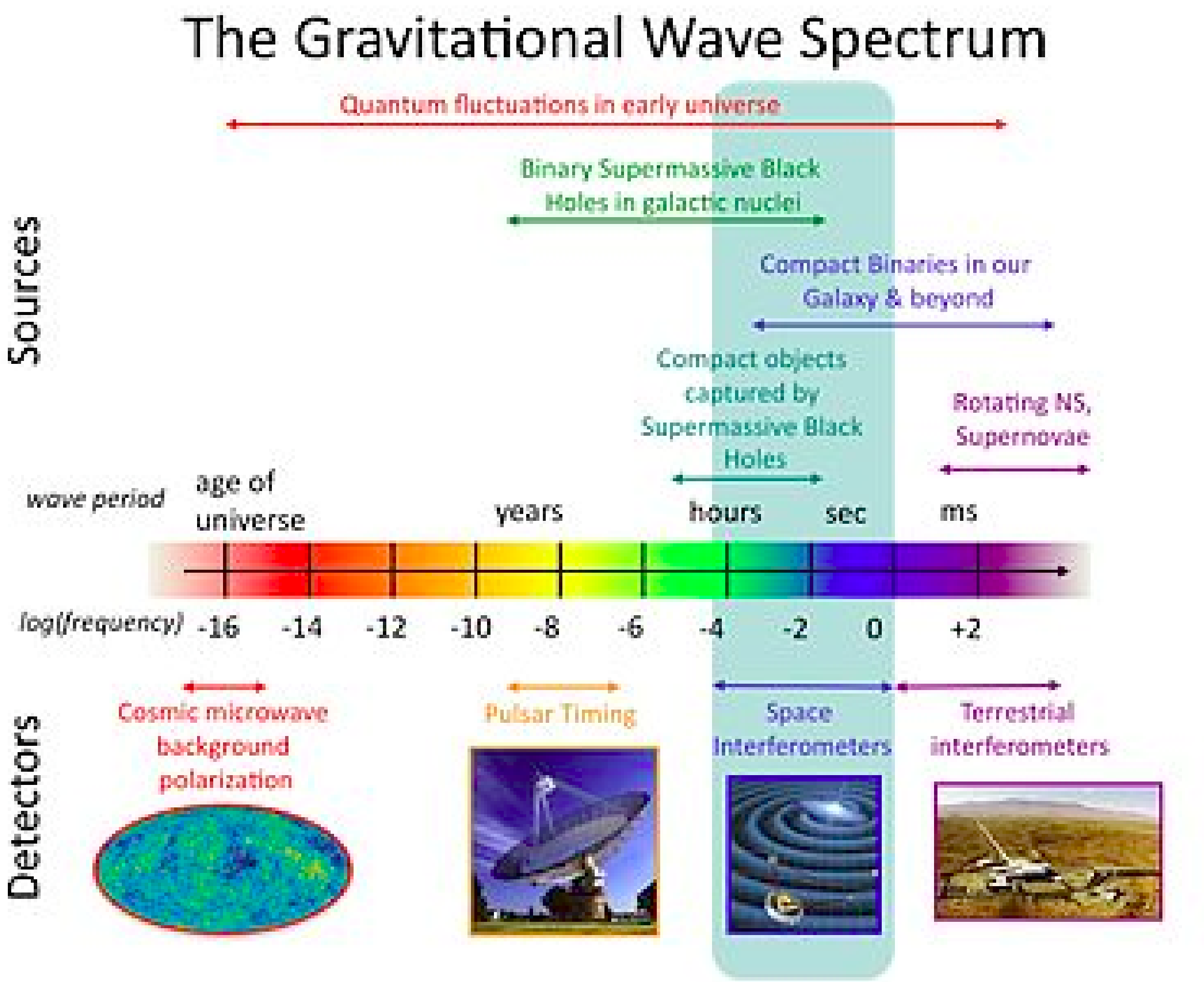
Accepted 2017 October 6. Received 2017 October 6; in original form 2017 June 22

Cosmologia com Ondas Gravitacionais

Objetivos central : Modificação da Relatividade geral, propriedades de Energia Escura e Materia Escura.



New observational constraints on $f(T)$ gravity through gravitational-wave astronomy

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(Received 10 October 2018; published 28 November 2018)

We investigate the new observational constraints on $f(T)$ gravity that arise from the effects of primordial gravitational waves (GWs) on the cosmic microwave background (CMB) anisotropies and the BB spectrum. We first show that on the GWs propagation in $f(T)$ gravity we obtain only an amplitude modification and not a phase one, comparing to the case of general relativity in the background of ΛCDM cosmology. Concerning primordial GWs we find that the more the model departs from general relativity the larger is the GW amplitude decay, and thus a possible future detection would bring the viable $f(T)$ gravity models five orders of magnitude closer to ΛCDM cosmology comparing to standard cosmological constraints. Additionally, we use the CLASS code and both data from the Planck probe, as well as forecasts from the near-future CORE collaboration, and we show that possible nontrivial constraints on the tensor-to-scalar ratio would offer a clear signature of $f(T)$ gravity. Finally, we discuss on the possibility to use the properties of the GWs that arise from neutron stars mergers in order to extract additional constrains on the theory.

DOI: 10.1103/PhysRevD.98.104055

Accepted Paper

Primordial gravitational waves in Horndeski gravity

Phys. Rev. D

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Accepted 31 March 2019

ABSTRACT

ABSTRACT

We investigate the propagation of primordial gravitational waves within the context of the Horndeski theories, for this, we present a generalized transfer function quantifying the sub-horizon evolution of gravitational waves modes after they enter the horizon. We compare the theoretical prediction of the modified primordial gravitational waves spectral density with the aLIGO, Einstein telescope, LISA, gLISA and DECIGO sensitivity curves. Assuming reasonable and different values for the free parameters of the theory (in agreement with the event GW170817 and stability conditions of the theory), we note that the gravitational waves amplitude can vary significantly in comparison with general relativity. We find that in some cases the gravitational primordial spectrum can cross the sensitivity curves for DECIGO detector with the maximum frequency sensitivity to the theoretical predictions around 0.05 - 0.30 Hz. From our results, it is clear that the future generations of space based interferometers can bring new perspectives to probing modifications in general relativity.

$$S[g_{\mu\nu},\phi] = \int \mathrm{d}^4x\,\sqrt{-g}\left[\sum_{i=2}^{5}\frac{1}{8\pi G_{\mathrm{N}}}\mathcal{L}_i[g_{\mu\nu},\phi] + \mathcal{L}_{\mathrm{m}}[g_{\mu\nu},\psi_M]\right]$$

$$\mathcal{L}_2 = G_2(\phi,\, X)$$

$$\mathcal{L}_3 = -G_3(\phi,\, X)\Box\phi$$

$$\mathcal{L}_4 = G_4(\phi,\, X)R + G_{4,X}(\phi,\, X)\left[(\Box\phi)^2 - \phi_{;\mu\nu}\phi^{;\mu\nu}\right]$$

$$\mathcal{L}_5 = G_5(\phi,\, X)G_{\mu\nu}\phi^{;\mu\nu} - \frac{1}{6}G_{5,X}(\phi,\, X)\left[(\Box\phi)^3 + 2\phi_{;\mu}{}^{\nu}\phi_{;\nu}{}^{\alpha}\phi_{;\alpha}{}^{\mu} - 3\phi_{;\mu\nu}\phi^{;\mu\nu}\Box\phi\right]$$

Trabalhos em fase final de preparação

Forecast on $f(T)$ gravity with gravitational waves from compact binary coalescences

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Listening to the sound of dark sector interactions with the Einstein Telescope

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Propostas gerais, perspectivas e trabalhos em andamento com Energia Escura e Gravidade modificada :

- Análise estatística de dados cosmologicos para modelos bem motivados e com novos ingredientes. Não testar/fazer coisas ja bem conhecidas/redundantes. Exemplos para investigação:

  Horndeski (and beyond) Gravity, f(T) Gravity, Massive Gravity, Novos acaplamentos entre particulas “ja conhecidas” e suas consequências, Interações Escuras.

- Verificar os limtes do modelo LambdaCDM + Nova fisica dentro das atuais tensões entre os dados de CMB e LSS.

- Análise de previsão baseada em futuros experimentos de CMB e LSS.

Propostas gerais, perspectivas e trabalhos em andamento com GWs

Propriedades da Matéria Escura, Energia Escua e limites da Relatividade Geral com:

- Análise estatística (Bayesiana e Fisher) para investigar eventos ja catalogados pelo LIGO/VIRGO e simulação para LISA e ET.

- Espectro primordial e suas impressões na RCF e interferômetros espaciais. Análise teórica e simulação estatística.

Propostas gerais, perspectivas e trabalhos em andamento com Neutrinos

- Problema da Hierarquia de massa em modelos alternativos.
- Dark radiation e possível nova família de neutrinos em dados astrofísicos e cosmologicos.
- Possível interação com Energia Escura.
- Impressão sobre ondas gravitacionais.


OBRIGADO
gracias
どうも
ARIGATO
hvala
DANK U
takk
MERSI
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obrigado
danke schön
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muchas gracias
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