MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Oswaldo Duarte Miranda

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Aonde me encontrar? Salas 12 & 14

Interesses e Áreas de Pesquisa

Gravitação e Ondas Gravitacionais

Teorias de gravitação alternativas a relatividade geral (Pedro Moraes - Doutorando)

Fontes astrofísicas e cosmológicas emissoras de ondas gravitacionais (buracos negros estelares e supermassivos, estrelas de nêutrons, sistemas binários......)

Ondas gravitacionais primordiais (inflação, pré-big-bang, ...) e pré-galácticas (primeiras estrelas do universo)

Cosmologia

Energia e matéria escuras (Carol Gribel - Mestrado)

Radiação cósmica de fundo em micro-ondas – laboratório para estudo de G&OG

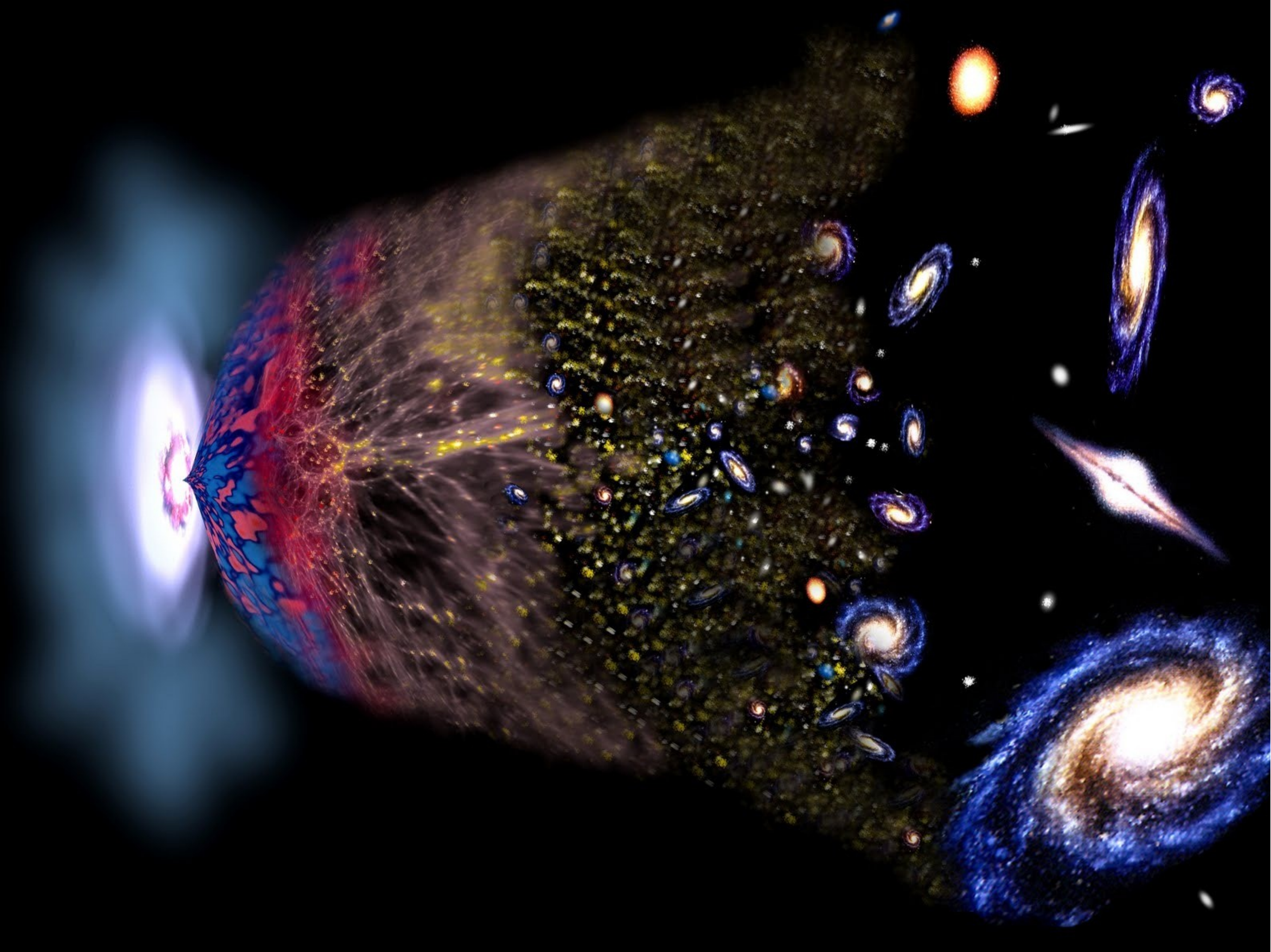
Formação e crescimento de buracos negros supermassivos (Eduardo S. Pereira - Pós-Doc)

Formação estelar – função de massa inicial e taxa de formação estelar (Carol Gribel - Doutorado)

Evolução química do universo a altos redshifts

(*) Plasmas Espacial/Astrofísico

Turbulência e simulações Magneto-Hidro-Dinâmicas (Odim Mendes da DGE e Margarete Domingues do LAC)



Alguns Resultados Recentes

Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

Mon. Not. R. Astron. Soc. **426,** 2758–2771 (2012) doi:10.1111/j.1365-2966.2012.21887.x

Stochastic backgrounds of gravitational waves from cosmological sources – the role of dark energy

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ABSTRACT

In this work we investigate the detectability of the gravitational stochastic background produced by cosmological sources in scenarios of structure formation. The calculation is performed in the framework of hierarchical structure formation using a Press–Schechter-like formalism. The model considers the coalescences of three kinds of binary systems, namely double neutron stars (NS–NS), the neutron star–black hole (NS–BH) binaries and the black hole–black hole (BH–BH) systems. We also included in the model the core-collapse supernovae leaving black holes as compact remnants. In particular, we use two different dark energy scenarios, specifically cosmological constant (Λ) and Chaplygin gas, in order to verify their influence on the cosmic star formation rate, the coalescence rates and the gravitational wave backgrounds. We calculate the gravitational wave signals separately for each kind of source and also determine their collective contribution for the stochastic background of gravitational waves. Concerning the compact binary systems, we verify that these sources produce stochastic backgrounds with signal-to-noise ratio (S/N) values $\sim$1.5 ($\sim$0.90) for NS–NS, $\sim$0.50 ($\sim$0.30) for NS–BH, $\sim$0.20 ($\sim$0.10) for BH–BH and $\sim$0.14 ($\sim$0.07) for core-collapse supernovae for a pair of advanced LIGO detectors in the cosmological-constant (Chaplygin gas) cosmology. Particularly, the sensitivity of the future third-generation detectors such as the Einstein Telescope (ET), in the triangular configuration, could increase the present S/N values by a high factor ($\sim$300–1000) when compared to the S/N calculated for advanced LIGO detectors. As an example, the collective contribution of these sources can produce S/N $\sim$ 3.3 ($\sim$1.8) for the Λ (Chaplygin gas) cosmology for a pair of advanced LIGO interferometers and within the frequency range $\sim$10 Hz–1.5 kHz. Considering ET we have S/N $\sim$ 2200 ($\sim$1300) for the Λ (Chaplygin gas) cosmology. Thus, the third-generation gravitational wave detectors could be used to reconstruct the history of star formation in the Universe and to contribute for the characterization of the dark energy, for example, identifying if there is evidence for the evolution of the dark energy equation-of-state parameter $w(a)$.

Key words: gravitational waves – binaries: close – stars: neutron – cosmology: theory – dark energy – large-scale structure of Universe.

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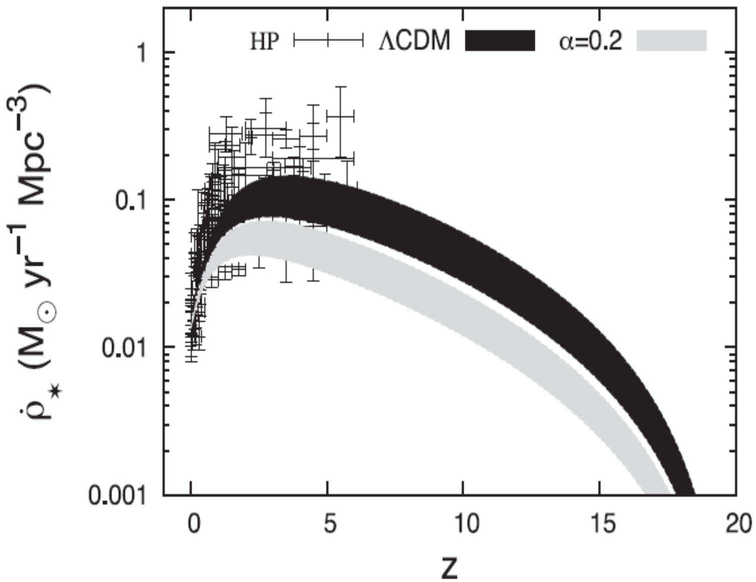

Figure 17. Possible CSFRs taking into account all the viable models studied in this work. The black area represents the family of CSFRs for the ΛCDM cosmology (models A1 to A3), while the grey area shows the family of CSFRs for the Chaplygin gas (models A4 to A6) as dark energy component of the Universe. Note that there is no overlap at $z > 2$ between these two dark fluids, with all the uncertainties in the parameters.

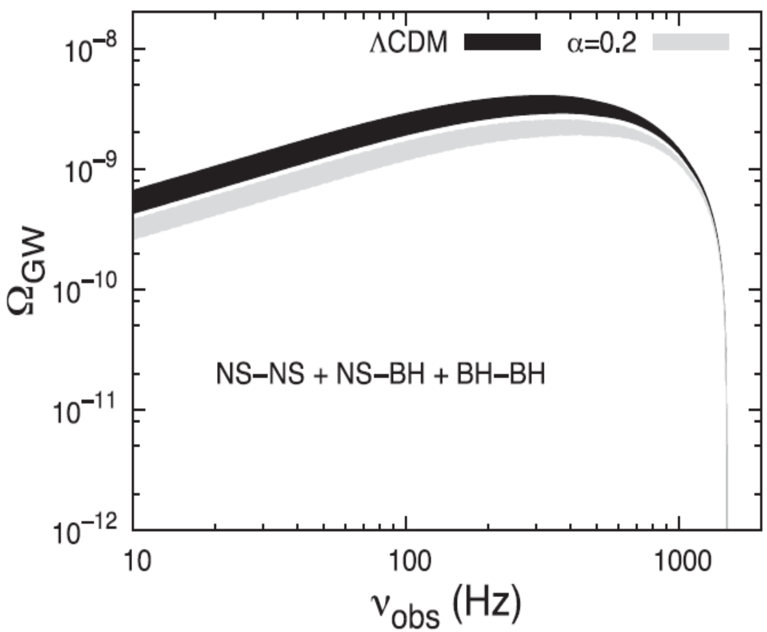

Figure 15. Collective spectra of the three compact binaries taking into account the uncertainties in the parameters. The black area describes all the possible GW signals for the ΛCDM case. The grey area represents the GW backgrounds for Chaplygin gas with $\alpha = 0.2$.

Alguns Resultados Recentes

Journal of Cosmology and Astroparticle Physics
An IOP and SISSA journal

Stochastic background of relic gravitons in a bouncing quantum cosmological model

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Abstract. The spectrum and amplitude of the stochastic background of relic gravitons produced in a bouncing universe is calculated. The matter content of the model consists of dust and radiation fluids, and the bounce occurs due to quantum cosmological effects when the universe approaches the classical singularity in the contracting phase. The resulting amplitude is very small and it cannot be observed by any present and near future gravitational wave detector. Hence, as in the ekpyrotic model, any observation of these relic gravitons will rule out this type of quantum cosmological bouncing model.

Keywords: gravitational waves / theory, alternatives to inflation

JCAP11(2012)054

Alguns Resultados Recentes

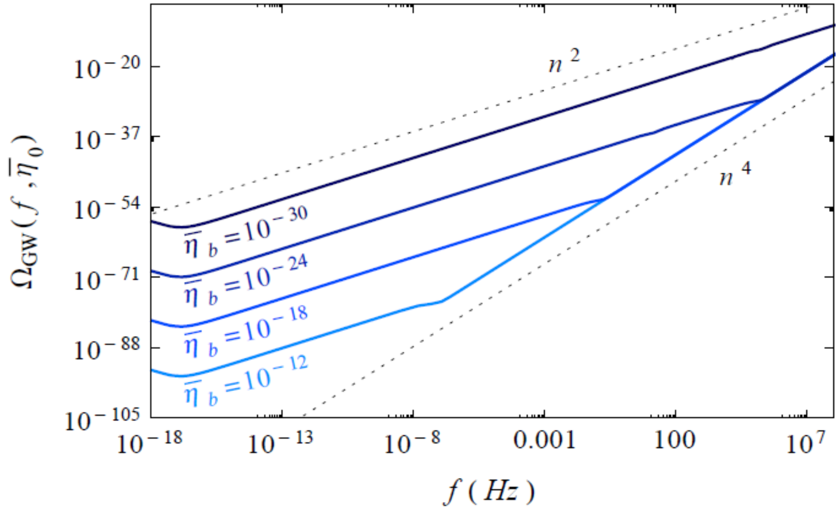

Figure 1. Energy density parameter as a function of frequency for the primordial gravitational waves produced in our model. Each curve shows the results obtained for the indicated value of $\bar{\eta}_b$. The dashed lines show for comparison two power laws proportional to n^2 and n^4.

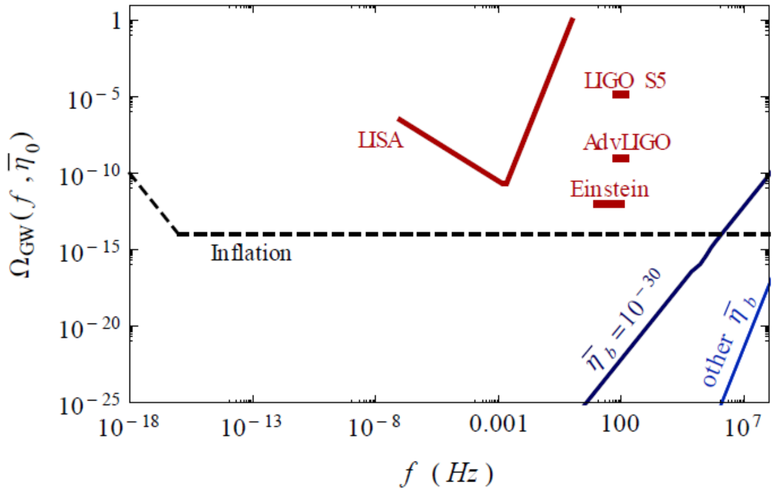

Figure 3. Comparison of our results (blue curves at the bottom right) with experimental sensitivities (red curves) and a prediction the upper limits on the spectrum of primordial gravitational waves generated in inflationary models (black dashed curve). The red curves show the sensitivities achieved by LIGO's 5th run and the ones predicted for Advanced LIGO, the Einstein Telescope and LISA [21].[3] See [22] and references therein.

Alguns Resultados Recentes

PHYSICAL REVIEW D **88,** 083530 (2013)

Probing a cosmological model with a $\Lambda = \Lambda_0 + 3\beta H^2$ decaying vacuum

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In this work we study the evolution of matter-density perturbations for an arbitrary $\Lambda(t)$ model and specialize our analysis to the particular phenomenological law $\Lambda = \Lambda_0 + 3\beta H^2$. We study the evolution of the cosmic star formation rate in this particular dark energy scenario and, by constraining the β parameter using both the age of the Universe and the cosmic star formation rate curve, we show that it leads to a reasonable physical model for $\beta \lesssim 0.1$.

TABLE I. The results for the CSFR as a function of the β parameter. In column 2 is presented the redshift (z_p) where the CSFR peaks, and finally, in column 3, we have the age of the Universe (t_u).

β	z_p	t_u (Gyr)
0	3.55	13.70
0.025	3.78	13.95
0.050	4.02	14.22
0.075	4.28	14.50
0.10	4.54	14.79

$$\Omega_{m,0} + \Omega_\Lambda = \frac{2}{3}\Delta, \tag{18}$$

where

$$\Omega_\Lambda \equiv \frac{\Lambda_0}{3H_0^2}, \qquad \Omega_m \equiv \frac{8\pi G\rho_{m,0}}{3H_0^2}; \tag{19}$$

hence, it follows from expression (16) that

$$E(a) = \sqrt{\frac{3}{2\Delta}\Omega_{m,0}\left(\frac{a}{a_0}\right)^{-2\Delta} + \frac{3}{2\Delta}\Omega_\Lambda}. \tag{20}$$

For a universe dominated by dust and the cosmological constant, that is, $\Delta = 3/2$, Eq. (20) reduces to the well-known formula for the ΛCDM model

$$E(a) = \sqrt{\Omega_{m0}(1+z)^3 + \Omega_\Lambda}, \tag{21}$$

as expected.

B. The equation for matter-density perturbations

Following Ref. [19], the hydrodynamical equations that describe the dynamics of the perfect fluid are given, respectively, by the Euler, continuity, and Poisson equations:

$$\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u}\cdot\nabla)\mathbf{u} = -\nabla\Phi + \frac{F}{\rho_m}(\mathbf{V} - \mathbf{u}), \tag{22}$$

$$\frac{\partial}{\partial t}\rho_m + \nabla\cdot(\rho_m \mathbf{u}) = F, \tag{23}$$

$$\nabla^2\Phi = 4\pi G\rho - \Lambda, \tag{24}$$

where $\mathbf{u}$ and $\mathbf{V}$ are, respectively, the velocity of a fluid volume element and of the created particles, ρ_m is the fluid mass density, Φ is the Newtonian gravitational potential, and F is the source term responsible for the matter creation due to the vacuum decay, given in Eq. (10).

We introduce next a comoving coordinate related to the proper coordinate $\mathbf{r}$ as

$$\mathbf{x} \equiv \frac{\mathbf{r}}{a} \tag{25}$$

and expand the velocity $\mathbf{u}$ and the matter density ρ_m to first order:

$$\mathbf{u} = aH\mathbf{x} + \mathbf{v}(\mathbf{x}, t), \tag{26}$$

$$\rho_m = \bar\rho_m(t)[1 + \delta_m(\mathbf{x}, t)], \tag{27}$$

where δ_m is the matter-density contrast; hence, Eqs. (22)–(24) become

$$\frac{\partial}{\partial t}\mathbf{v} + H\mathbf{v} + \ddot a\mathbf{x} = -\frac{1}{a}\nabla\Phi, \tag{28}$$

$$\nabla\cdot\mathbf{v} = -a\left(\frac{\partial}{\partial t}\delta_m + Q\delta_m\right), \tag{29}$$

$$\nabla^2\Phi = 4\pi G a^2\bar\rho_m(1+\delta_m) - \Lambda^2 a^2, \tag{30}$$

where we have used Eq. (9) to zeroth order and defined

$$Q(t) \equiv \frac{F}{\rho_0}. \tag{31}$$

Next, by expanding Φ as

$$\Phi(\mathbf{x}, t) = \phi(\mathbf{x}, t) + \frac{2\pi}{3}G\bar\rho_m a^2x^2 - \frac{1}{6}\Lambda a^2x^2 \tag{32}$$

and using the background equation (11) with $w = 0$, expressions (28) and (30) turn into

$$\frac{\partial\mathbf{v}}{\partial t} + H\mathbf{v} = -\frac{1}{a}\nabla\phi, \tag{33}$$

$$\nabla^2\phi = 4\pi G a^2\bar\rho_m\delta_m. \tag{34}$$

Taking the divergence of (33) and using (29) and (34), we find

$$\ddot\delta_m + (2H + Q)\dot\delta_m - (4\pi G\bar\rho_m - 2HQ - \dot Q)\delta_m = 0. \tag{35}$$

Next we change the cosmic time variable t into the scale factor, so that Eq. (35) becomes

$$\delta_m'' + \left[\frac{3}{a} + \frac{E'}{E} - \frac{a^3\Lambda'}{3H_0^2\Omega_{m,0}}\right]\delta_m' - \left[\frac{3}{2}\frac{\Omega_{m,0}}{a^5E^2} + \frac{a^3}{3H_0^2\Omega_{m,0}} \times\left(6\frac{\Lambda'}{a} + \frac{E'}{E}\Lambda' + \Lambda''\right)\right]\delta_m = 0. \tag{36}$$

It is important to stress that Eq. (36) is quite general, holding for *any* cosmological model with $\Lambda(t)$, thus generalizing the approach developed in [17]. In particular, it reduces to the ΛCDM matter-density contrast when $\Lambda' = 0$:

$$\delta_m'' + \left(\frac{3}{a} + \frac{E'}{E}\right)\delta_m' - \frac{3}{2}\frac{\Omega_{m,0}}{a^5E^2}\delta_m = 0 \tag{37}$$

[see Eq. (19) in Ref. [17]].

III. THE HIERARCHICAL STRUCTURE FORMATION SCENARIO

A. The halo mass function

Press and Schechter (hereafter PS) heuristically derived a mass function for bounded virialized objects in 1974 [20]. The basic idea of the PS approach is to define halos as concentrations of mass that have already left the linear regime by crossing the threshold δ_c for nonlinear collapse. Thus, given a power spectrum and a window function, it should then be relatively straightforward to calculate the halo mass function as a function of the mass and redshift. In particular, the scale differential mass function $f(\sigma, z)$ [21], defined as a fraction of the total mass per $\ln\sigma^{-1}$ that belongs to halos, is

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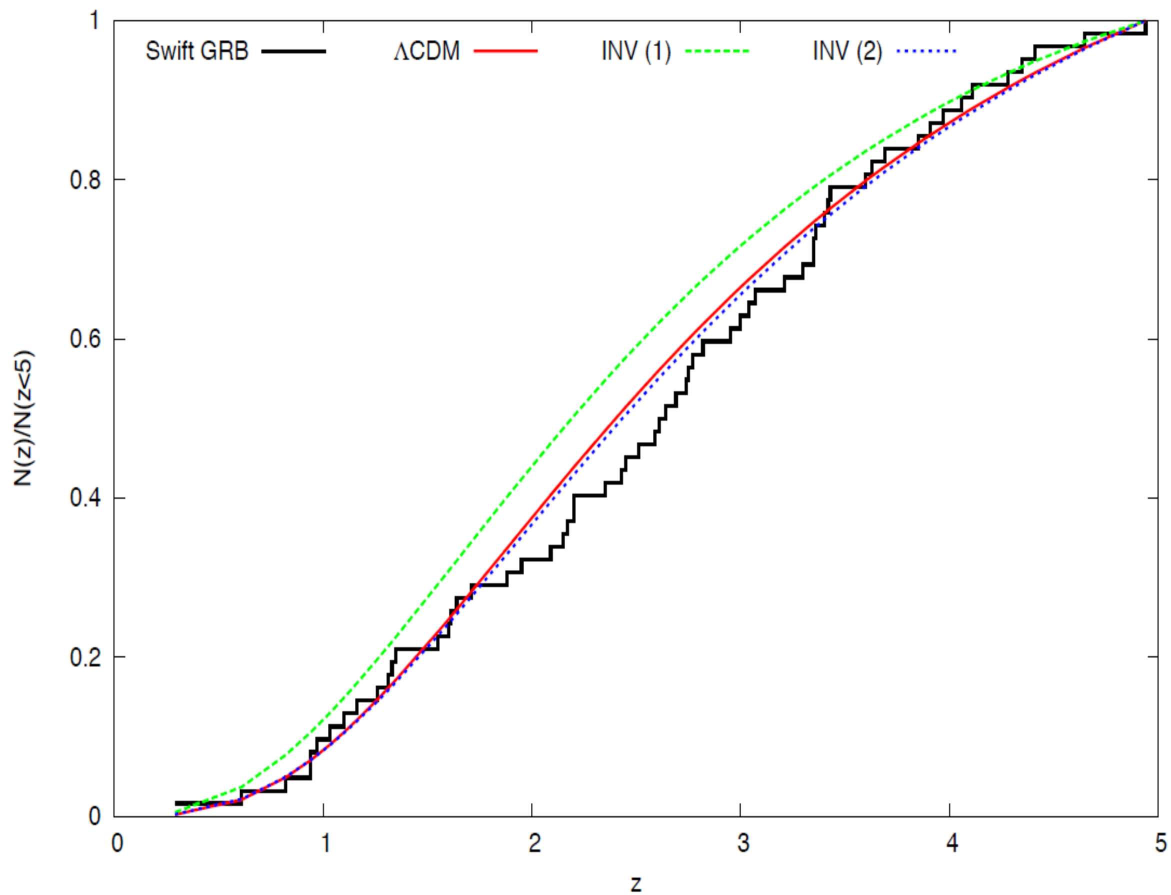
aa/bb/cc/dd-TDI

CONFRONTANDO MODELOS DE ENERGIA ESCURA COM A TAXA CÓSMICA DE FORMAÇÃO ESTELAR, LGRB, E FUNDOS ESTOCÁSTICOS DE ONDAS GRAVITACIONAIS.

Carolina Gribel de Vasconcelos Ferreira

Dissertação de Mestrado do Curso de Pós-Graduação em Astrofísica, orientada pelo Dr. Oswaldo Duarte Miranda.



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UMA CONTRIBUIÇÃO AO ESTUDO DO ENRIQUECIMENTO QUÍMICO DO UNIVERSO

Marcela Vitti

Dissertação de Mestrado do Curso de Pós-Graduação em Astrofísica, orientada pelos Drs. Oswaldo Duarte Miranda, e André de Castro Milone, aprovada em 17 de dezembro de 2012.

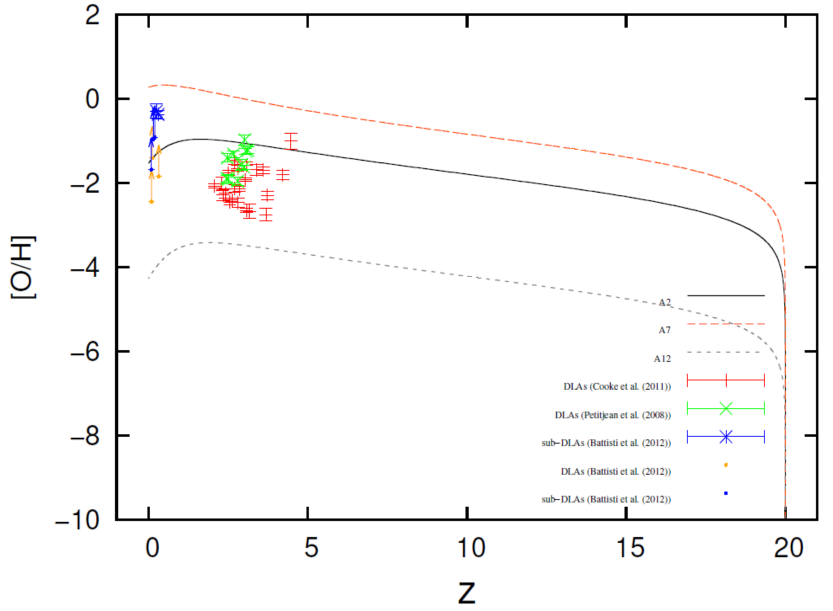

Figura 7.15 - Modelo A para População III com $x = 1,35$, $x = 0,35$ e $x = 2,35$, e $\tau = 2$(Gyr).

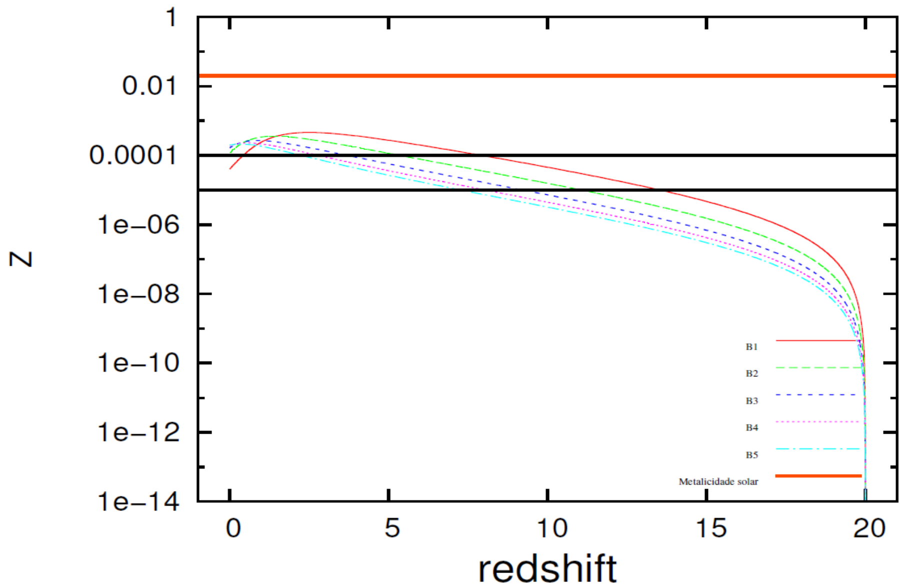

Figura 7.44 - Metalicidade total, as duas linhas escuras na horizontal representam as possíveis metalicidades de transição entre a População III e a População II. Modelo B para População III com $x = 1,35$ e τ variando de 1 a 5(Gyr).

Passos Importantes para os Novos Alunos

Passo 1: Conheça as teses e dissertações (talvez você se identifique com algum trabalho)

Passos Importantes para os Novos Alunos

Passo 2: Conheça os possíveis orientadores e seus CVs

Docentes Permanentes	Ramal	E-mail	Lattes
André de Castro Milone *Doutor, USP 1996*	(12) 3208-7209	andre.milone@inpe.br	Lattes
Carlos Alexandre Wuensche de Souza *Doutor, INPE 1995*	(12) 3208-7197	ca.wuensche@inpe.br	Lattes
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Dennis Fernandes Alves Bessada	(11) 3319-3539	dennis.bessada@unifesp.br	Lattes
Emilia Correia *Doutora, INPE 1989*	(11) 2114-8726	ecorreia@craam.mackenzie.br	Lattes
Francisco José Jablonski *Doutor, USP 1989*	(12) 3208-7205	chico@das.inpe.br	Lattes
João Braga *Doutor, USP 1990*	(12) 3208-6029 (12) 3208-7215	joao.braga@inpe.br	Lattes
Joaquim Eduardo Rezende Costa *Doutor, INPE 1990*	(12) 3208-7201	joaquim.costa@inpe.br	Lattes
José Carlos Neves de Araujo *Doutor, USP 1990*	(12) 3208-7223	jcarlos.dearaujo@inpe.br	Lattes
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Thyrso Villela Neto	-	thyrso.villela @inpe.br	Lattes

Docentes Colaboradores	Ramal	E-mail	Lattes
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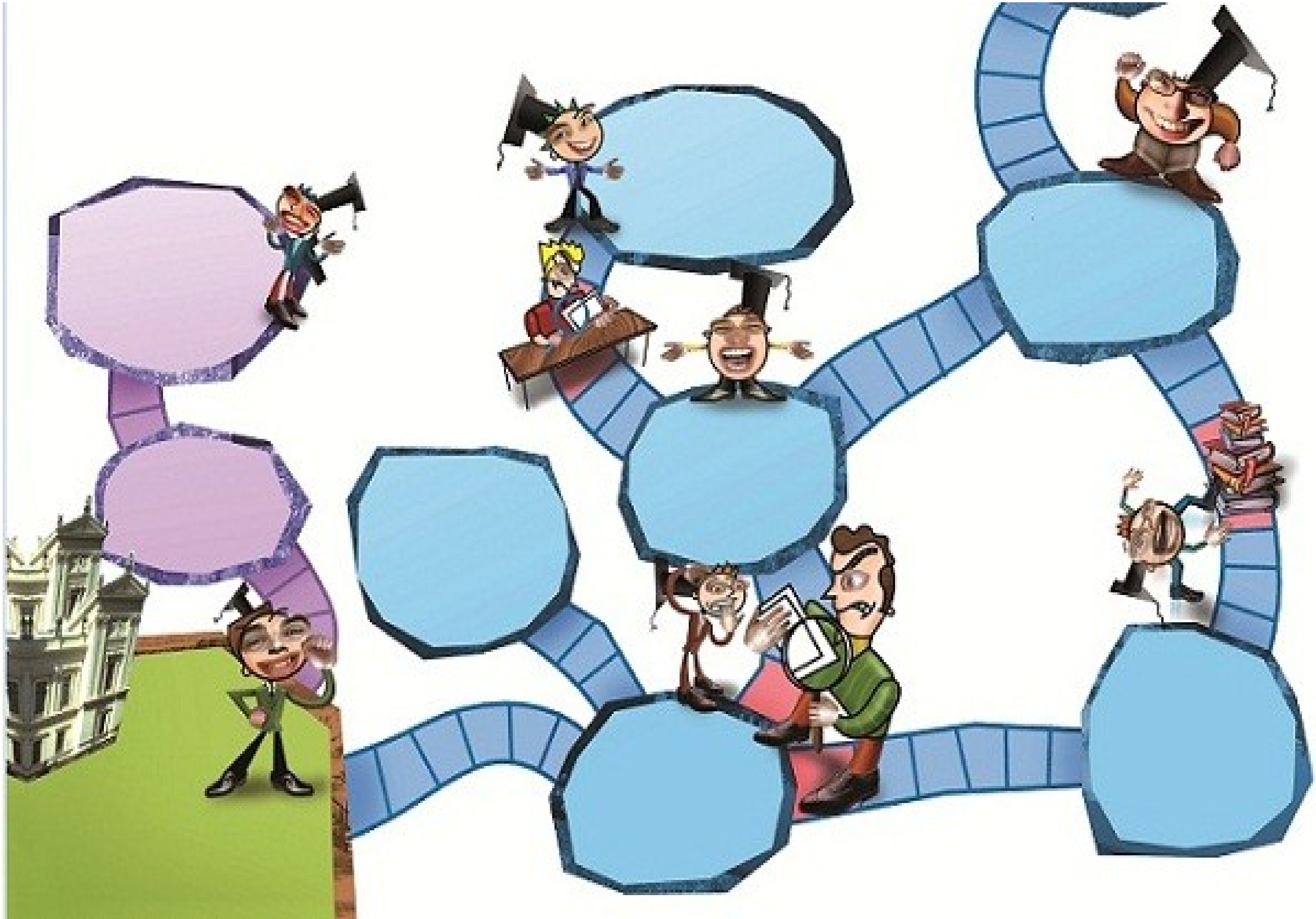
José Roberto Cecatto *Doutor. INPE 1996*	(12) 3208-7221	jrc@das.inpe.br	Lattes

Passos Importantes para os Novos Alunos

Passo 3: Identifique o tempo médio para titulação dos estudantes já formados



Passos Importantes para os Novos Alunos

Passo 4: Após ter concluído passos 1, 2 e 3 você deve ter chegado num conjunto de nomes de possíveis orientadores. É hora de conversar (Don't worry, be happy)

Passos Importantes para os Novos Alunos