

A Research Study on Quasi Steady State Cosmology

R.K. Pathak¹, Seema Pandey²

Department of Applied Sciences, B.N. College of Engineering and Technology Lucknow (U.P.) India¹

Professor, Department of Physics, JECRC, Jaipur, Rajasthan, India²

ABSTRACT: We present gravitational wave background (GWB) in the quasi-steady state cosmology (QSSC), by considering the mini-creation events (MCV) being the sources of gravitational waves. We present analytical method to evaluate the gravitational background with proper assumptions.

KEYWORDS: Quasi-Steady State Cosmology (QSSC), Mini-Creation Events (MCV), Machian theory

I. INTRODUCTION

Hoyle, Burbidge and Narlikar (1993) proposed the quasi-steady state cosmological model. Hoyle and Narlikar (1964, 1966) modified the theory by considering of matter and Machian theory of gravity. They described that creation terms in the form of negative energy scalar field. They also introduced cosmological term λ similar to Λ with opposite sign. The field equations read

$$R_{ik} - \frac{1}{2} g_{ik} R + \lambda g_{ik} = -\frac{8\pi G}{c^4} \left[T_{ik} - f \left(C_i C_k - \frac{1}{4} g_{ik} C^\ell C_\ell \right) \right], \quad (1)$$

where λ be the another cosmological constant having negative sign and f as the coupling constant. Let us consider the Robertson-Walker metric with vanishing curvature parameter k as

$$ds^2 = c^2 dt^2 - S^2(t) \left[dr^2 + r^2 (d\theta^2 + \sin^2 \theta d\phi^2) \right], \quad (2)$$

where $S(t)$ be the scale factor of the universe.

Hoyle, Burbidge and Narlikar (2000) have given comprehensive account of QSSC model in a technical monograph.

II. GRAVITATIONAL WAVE BACKGROUND

Narlikar (2002), presented the formula that a source with red shift z having luminosity L may be described by a spectrum $F(\nu) d\nu$ such that

$$\int_0^\infty F(\nu) d\nu = 1. \quad (3)$$

Hence, the flux of radiation over unit normal area in the frequency band ν and $\nu+d\nu$, reads

$$\zeta(\nu) = \frac{LF(\nu \cdot \bar{1} \bar{+} \bar{z})}{4\pi r^2 S_0^2 (1+z)}, \quad (4)$$

at all past epochs i.e. at

$$t_n = -\left(n - \frac{1}{2} \right) Q, \quad (5)$$

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where $n = 0, 1, 2, \dots$, and corresponding red shifts read

$$z_n = \frac{S(t_0)}{S(t_n)} - 1, \tag{6}$$

$$= \exp \frac{t_0 - t_n}{p} \cdot \frac{1 + \eta \cos 2\pi t_0 / Q}{1 - \eta} - 1.$$

Let us consider an observer is located at $r = 0$ at present epoch t_0 . Therefore, the radiation pulse emitted by a mini-creation event may reach to an observer, having distance r_n as

$$r_n = \int_{t_n}^{t_0} c dt / S(t). \tag{7}$$

Let us consider a thin shell of radial thickness of the form

$$\Delta = (1 + z_n)^{-1} \text{ second.} \tag{8}$$

by giving gravitational radiation at $r = 0$ to the observer and lasting for one second. Hence, the volume of the shell reads

$$\Delta V_n = 4\pi r_n^2 (1 + z_n)^{-1} S_0^2 c. \tag{9}$$

This is Euclidean formulation. It is expected that non-Euclidean geometry may modify the above formulation. Therefore the number of mini-creation events which give rise to gravitational wave background read as

$$\Delta v_n \cdot N \tag{10}$$

The flux density $\varphi_n(v) dv$ over the range of frequencies, v , and $v+dv$ by each mini-creation events, where

$$\varphi_n(v) dv = \frac{G\alpha M^2 u^4 v_{\min} dv}{\pi r_n^2 c^5 v^2 (1 + z_n)^3 S_0^2}, \tag{11}$$

for $n = 0, 1, 2, \dots$

Hence, the total flux density due to all mini-creation events reads

$$B(v) dv = \sum_{n=0}^{\infty} \frac{4\alpha GM^2 u^4 v_{\min} N}{c^4 v^2 (1 + z_n)^4} dv. \tag{12}$$

Let us put $P = 20 Q$, $Q = 42 \text{ Gyr}$, $\eta = 0.85$ and

$$N = p \left[1 - \exp\left(-\frac{3Q}{p}\right) \right] (qTM_{\square})^{-1}, \tag{13}$$

so one may obtain the equation for gravitational wave flux as

$$B(v) = \frac{4\alpha GM^2 u^4 v_{\min}}{c^4 v^2} \frac{\rho_0}{qTM_{\square}} \times \left(\frac{0.15}{1 + 0.85(\cos 1.6\pi)} \right) e^{-0.015} (1 - e^{-\frac{3}{20}}) \times \sum_{n=0}^{\infty} \exp\left(-\frac{n}{5}\right). \tag{14}$$

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By summing the series in the eq. (14) we get

$$\sum_{n=0}^{\infty} \exp\left(-\frac{n}{5}\right) = 5.52. \quad (15)$$

Let us put $u = 8.0c$, $T = 1000$ sec, the eq. (14) gives

$$\int_{v_{\min}}^{\infty} B(v) dv \approx 6.8 \times 10^5 \left(\frac{T}{1000}\right)^{-1} \text{ ergs cm}^{-2} \text{ s}^{-1} \quad (16)$$

Hence, the gravitational wave flux per unit frequency reads

$$B(v) \approx 6.8 \times 10^5 \frac{v_{\min}}{v^2} \left(\frac{T}{1000}\right)^{-1} \text{ ergs cm}^{-2} \text{ s}^{-1} \text{ Hz}^{-1}. \quad (17)$$

Therefore, one may evaluate the expected energy density of gravitational waves

$$\Omega_{GW}(v) \approx 1.4 \times 10^{12} \left(\frac{v}{10 \text{ Hz}}\right)^{-2} \left(\frac{T}{1000 \text{ sec}}\right)^{-2}. \quad (18)$$

For $T \leq 160$ sec,

$$\Omega_{GW}(v) \approx 5 \times 10^{11}. \quad (19)$$

III. CONCLUSION

We have presented the gravitational wave background analytically in quasi-steady state cosmological model.

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