Astrophys Space Sci (2013) 347:193–196
DOI 10.1007/s10509-013-1500-8

ORIGINAL ARTICLE

Cosmic Background Bose Condensation (CBBC)

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Received: 16 March 2013 / Accepted: 16 May 2013 / Published online: 30 May 2013

Abstract Degeneracy effects for bosons are more important for smaller particle mass, smaller temperature and higher number density. Bose condensation requires that particles be in the same lowest energy quantum state. We propose a cosmic background Bose condensation, present everywhere, with its particles having the lowest quantum energy state, $\hbar c/\lambda$, with λ about the size of the visible universe, and therefore unlocalized. This we identify with the quantum of the self gravitational potential energy of any particle, and with the bit of information of minimum energy. The entropy of the universe ($\sim 10^{122}$ bits) has the highest number density ($\sim 10^{36}$ bits/cm^3) of particles inside the visible universe, the smallest mass, $\sim 10^{-66}$ g, and the smallest temperature, $\sim 10^{-29}$ K. Therefore it is the best candidate for a Cosmic Background Bose Condensation (CBBC), a completely calmed fluid, with no viscosity, in a superfluidity state, and possibly responsible for the expansion of the universe.

Keywords Bose condensation · Entropy · Cosmology · Gravitation · Universe · Hawking temperature · Unruh temperature · Quantum of mass

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1 Introduction

Weinberg (1972) advanced a clue to suggest that large numbers are determined by both, microphysics and the influence of the whole universe. He constructed a mass using the physical constants G, $\hbar$, c and the Hubble parameter H. This mass was not too different from the mass of a typical elementary particle (like a pion) and is given by

$$m \approx \left(\hbar^2 H/Gc\right)^{1/3} \tag{1}$$

In our work here we consider a general elementary particle of mass m. This particle may include not only baryons but the possible quantum masses of dark matter and dark energy in the universe. Since the mass m will disappear from the resultant relation, the conclusion is totally independent on the kind of elementary particle that we may consider. The self gravitational potential energy E_g of this quantum of mass m (and size its Compton wavelength $\hbar/mc$) is given by

$$E_g = Gm^2/(\hbar/mc) = Gm^3c/\hbar \tag{2}$$

This relation has been previously used in another context (Sivaram 1982). Combining (1) and (2) we eliminate the mass m to obtain

$$E_g \approx H\hbar \tag{3}$$

Here $\hbar$ is Planck's constant, usually interpreted as the smallest quantum of action (angular momentum). Since H is of the order of $1/t$, t the age of the universe (t being a maximum time today), (3) is the lowest quantum energy state that it may exist. It is equivalent to $\hbar c/\lambda$ with λ of the order of the size of the visible universe (it is the lowest quantum energy state with $\lambda \approx ct$). We identify it with the quantum of the self gravitational potential energy of any quantum particle (Alfonso-Faus 2010a). We also identify it with the