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Distribution of Hot and Cold Dark Matter in the Universe

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ABSTRACT

A solution of Friedman equation argues that hot dark matter drives an accelerating universe. Reviewing the recent observational data with the model, a new model of distribution of hot and cold dark matter is obtained.

KEY WORDS: *Hot dark matter, Friedman equation, accelerating universe*

INTRODUCTION

Recently we have obtained a solution of Friedman equation that argues hot dark matter drives the accelerated universe. Combining the recent observational data with the fact that hot dark matter drives an accelerating universe, a new model of distribution of hot and cold dark matter is obtained. In this model, cold-dark matter is concentrated in the center of Galaxies and hot-dark matter is distributed in the near of the walk. Furthermore, probing of the model with current experimental observations is considered.

A suitable derivation of Friedman equation is able to disclose the acceleration character of the cosmos. When we consider the Fishler-Susskind particle horizon approach, one obtains $\rho_\Lambda \approx a^{-2(1+1/c)}$ which implies $w_H > -1/3$ that corresponds to a decelerating universe[1]. To resolve this situation, there are two choices, using the future particle horizon in the framework of holographic universe[2] and solution of Friedman equation for hot dark matter, for example massive neutrinos [3]. In this scenario we can write,

$$L_\Lambda = R_H = a\int_t^\infty (dt/a) = a\int_a^\infty (da/Ha^2) \tag{1}$$

Where $H^2 = \frac{8\pi\rho_\Lambda}{3M^2{}_p}$. Leading to an integral equation $HR_H = c$ one obtains [3],

$$c\frac{d}{dt}\left(\frac{H^{-1}}{a}\right) = -\frac{1}{Ha^2} \tag{2}$$

In this case we obtain,

$$\rho_\Lambda \approx a^{-2(1-1/c)} \tag{3}$$

Which implies $w_H = -1/3(1+2/c)$ that corresponds to an accelerating universe.

Both methods are interesting but solution of Friedman equation for hot dark matter is an attention-getting topic for (at least) an important reason: using this approach we obtain the picture of distribution of dark matter in the cosmos. Let we probe the model with the current experimental observations. A recent study of the x-ray emission of hot gas in a massive cluster of galaxy has allowed to astronomers to determine the distribution of its dark matter content [4]. The density of dark matter appears to increase towards the center of the cluster in agreement with cold-dark matter predictions. The x-ray data shows that the dark matter density increases smoothly all the way into the central galaxy of the cluster. Recently, there has been growing evidence in favor of the cold-dark matter model. The Wilkinson Microwave Anisotropy Probe has shown that normal baryonic matter only accounts for 17 percent of the matter content of the

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universe; the rest being cold-dark matter of unknown nature. Dark matter particles have the property of interacting with each other and with normal baryonic matter. These weakly interacting massive particles (WIMPs) are difficult to be detected and have been elusive until now. Massive neutrinos are a possible dark matter candidate; they are named hot dark matter because they travel at close to the speed of light. Due to this high speed, hot dark matter, on the one hand creates the big structures of the size of galaxy cluster first, which then fragment to form galaxies and on the other hand, using the hot dark matter solution of the Friedman equation we obtain an accelerating universe. By contrast, the slower (cold) dark matter particles cannot travel as far and so form small galaxies first, which then merge to form bigger structures such as clusters of galaxies [4]. This picture of dark matter argues that hot dark matter drives on accelerating universe no cold dark matter [3] that is in agreement with the new explanation, which the researchers refer to it as the super Hubble cold dark matter model[5], this model considers what would happen if there were cosmological perturbations with very long wavelength larger than the size of observable universe. In the SHCDM model it is shown that a local observable would infer an expansion history of the universe would depend on the time evaluation of the perturbations, which in certain case would lead to the observation of accelerated expansion. The origin of the long-wavelength perturbations is inflation; as effectively the visible universe is only a tiny part of the pre-inflation-era universe. The accelerating universe is therefore simply an impression due to our inability to see the full picture. Of course, observation is the ultimate arbiter between theories. The SHCDM model [5] predicts a different relationship between luminosity-distance and red shift than the dark energy models. But it is in agreement with the recent picture of dark matter, because in this model only and only hot dark matter is responsible of acceleration of the universe. So in this model cold dark matter is concentrated in the center of the galaxies and hot dark matter is distributed in the near of walk. The fact that dark matter is distributed over large distances implies that it undergoes little energy loss, so any interactions must be weak. Therefore both hot dark matter particles and cold dark matter particles are generically called WIMPs, for weakly interacting massive particles. The WIMPs must, however, be able to annihilate if they were produced in the thermal equilibrium with all other particles in the early universe. At that time the numbers of densities of different particles were the same order of magnitude and just as the baryon/photon ratio was reduced by 10 orders of magnitude by baryon annihilation. However both hot dark matter and cold dark matter are WIMPs but only cold dark matter collide and annihilate into quark pairs. These in turn will produce stable particles including gamma ray. Of course this assumes that gamma ray from cold dark matter annihilation can be differentiated from the background but this is indeed possible, sine the spectral shapes are very different, as can be understood as follows. Cold WIMPs have almost no kinetic energy but hot WIMPs carries a kinetic energy (because of the speed) so after the annihilation of cold WIMPs into quark pairs their mass is converted into the energy of quarks. The gamma ray produced in the fragmentation of such mono-energetic quarks have been well studied at the CERN Large Electron Positron Collider, they originate mainly from the decay of the copiously produced π° mesons. But interaction of hot WIMPs is not studied until now[13].

Conclusion

Recent observational data shows that our universe is in an accelerating phase of expansion. A solution of Friedman equation presented that argues that hot dark matter drives an accelerating universe.

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