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A Better Candidate for Dark Matter is Cosmic Plasma

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Abstract

In the ΛCDM cosmological model, based on observations of supernovae Ia, the cosmic dark energy density is assumed to be $\Omega_\Lambda \sim 0.70$ and the gravitational mass density is assumed to be $\Omega_m \sim 0.30$. Based on the assumption that the observed cosmic microwave background (CMB) is a thermal relic of the early hot universe, the cosmic plasma density should be small, i.e., $\Omega_b \sim 0.05$ (otherwise the Sunyaev-Zeldovich effect of the cosmic plasma would ruin the observed CMB's perfect blackbody spectrum). To fill the gap between Ω_m and Ω_b, non-baryonic dark matter $\Omega_c \sim 0.25$ is introduced into the ΛCDM model. If the CMB is the result of a partial thermal equilibrium between cosmic radiation and cosmic plasma, then the observed perfect blackbody spectrum of the CMB can coexist with cosmic plasma. In this case, it is not necessary to introduce non-baryonic cold dark matter into cosmological models. A better candidate for dark matter is the cosmic plasma.

Key words: cosmology: theory – (cosmology:) dark matter – gravitational lensing: weak – X-rays: galaxies: clusters

1. Introduction

There are many cosmological models in cosmology (Lopez-Corredoira & Marmet 2022). Currently, the ΛCDM model is considered the standard cosmological model. Observations show that the universe is flat. Based on observations of supernovae Ia (Riess et al. 1998; Perlmutter et al. 1999), in the ΛCDM model, it is assumed

$$\Omega_\Lambda + \Omega_M \simeq 1 \tag{1}$$

where Ω_Λ is dark energy ($\Omega_\Lambda \sim 0.70$), Ω_M is mean gravitational mass density, $\Omega_M \sim 0.30$).

In the ΛCDM model, the gravitational mass density Ω_M consists mainly of two parts: Ω_b is the density of baryons that we know exist, and Ω_c is the hypothetical non-baryonic cold dark matter (Peebles & Bharat 2003). That is

$$\Omega_M \simeq \Omega_b + \Omega_c \tag{2}$$

Why do astrophysicists introduce the hypothetical non-baryonic cold dark matter into the CDM model? Because most astrophysicists believe that the observed cosmic microwave background (CMB) is a thermal relic of the early hot universe. This idea is based on a conjecture put forward by Gamow et al. in the 1940 s (Sunyaev & Zeldovich 1980; Peebles & Seager 2000; Peebles 2017).

The hypothetical scenario of Gamow et al. is that after $z < 1000$, the primeval plasma should combine to form neutral baryons. Therefore, at present, the universe should be a free ocean of thermal radiation. Thus, the perfect blackbody thermal radiation spectrum of the early hot universe can be maintained, only the spectral temperature decreases as the universe expands (Peebles & Seager 2000).

This idea of the evolution of the universe clearly conflicts with the real universe. Observations show that almost all baryons are in the state of high temperature ionized gases (Fukugita et al. 1998). In order to explain this fact, the theory of reionization has been proposed (e.g., Becker et al. 2001). Even so, if the gravitational mass density ($\Omega_M \sim 0.30$) consists of a variety of fully ionized gases, then the Sunyaev-Zeldovich (S-Z) effect caused by free electrons in the cosmic plasma will disrupt the observed CMB's perfect blackbody spectrum (Sunyaev & Zeldovich 1980; Zheng 2021).

In order to minimize the effect caused by the cosmic plasma, the mass density of baryons must be limited to a small value. That is why in ΛCDM model, the hypothetical non-baryonic cold dark matter has been proposed to fill the gap between the gravitational mass density ($\Omega_M \sim 0.30$) and the mass density of baryons ($\Omega_b \sim 0.05$) (Planck Collaboration 2014a, 2014b).

Many candidates of non-baryonic particles have been proposed, and many astronomical observations have been carried out trying to find these imaginary non-baryonic particles, but none of them have been confirmed (AMS Collaboration 2013; XENON100 Collaboration 2013; PandaX Collaboration 2014; Fornasa et al. 2016; ANTARES Collaboration 2016). This means that the introduction of non-baryonic dark matter into cosmological model is only a conjecture. David et al. (1995) pointed out that as new spectral windows have opened to astronomers, cosmic plasma, previously termed dark matter, has been found to emit radiation profusely in X-ray band of the radiation spectrum. Therefore, a better candidate for dark matter is cosmic plasma.

Since almost all observed baryons in the universe are ionized, the best way to determine their mass density is to measure the X-ray radiation they emit. Observations of the diffuse soft X-ray background suggest that the density of cosmic plasma may be much greater than estimated by the ΛCDM model (Wang & McCray 1993; Fukugita et al. 1998). Unfortunately, in order to maintain the unreasonable assumptions of Gamow et al., reasonable observations were ignored in two well-known articles. This is why the mystery of "dark matter" has remained unsolved for nearly a century (de Swart et al. 2017). The two well-known articles are:

I. In "THE COSMIC BARYON BUDGET" (Fukugita et al. 1998), Fukugita et al. noted the findings of Wang and McCray. It is only because Fukugita et al. argued that: "On theoretical grounds, however, it is difficult to see how there could be much mass in void plasma," this component of the cosmic plasma was unreasonably omitted from their article. Thus, they conclude that the best mass density of baryons is $\Omega_b \sim 0.021$ (please refer to 2.6.1. *Warm Plasma in the Voids* in Fukugita et al. 1998).

II. In "Planck 2013 results. I. Overview of products and scientific results," the prior range of the baryonic mass density of the universe $\Omega_b h^2$ is set to be [0.005–0.1]. Under this assumption, they came up with the best fit for $\Omega_b h^2 \sim 0.022$. This means that the mass density of baryons is $\Omega_b \sim 0.049$ (see Table 9 and Table 10 in Planck Collaboration 2014a) or (see Table 1 and Table 2 in Planck Collaboration 2014b).

The crux of the matter is that most astrophysicists believe that the observed CMB is the thermal relic of the early hot universe. If the gravitational mass consists almost entirely of cosmic plasma, then the spectrum of the observed CMB will not maintain the perfect blackbody spectrum of the early hot cosmic radiation. It would be destroyed by the S-Z effect caused by cosmic plasma.

If gravitational matter entirely consists of cosmic plasma, then a theory must be found to explain why the observed perfect blackbody spectrum of CMB can harmoniously coexist with the abundance of cosmic plasma in the universe.

One possible and interesting explanation for CMB is that the observed CMB is the result of a partial thermal equilibrium between cosmic radiation and cosmic plasma (Zheng 2021). In this case, the density of the cosmic plasma Ω_b can be as large as the gravitational mass density Ω_m. This idea has been supported by observations (Wu 2000; Xue & Wu 2002). So there is no need to introduce non-baryonic cold dark matter Ω_c into the ΛCDM model. A better candidate for dark matter is cosmic plasma.

2. Various Estimates of Mass Density of Cosmic Baryons

2.1. The Cosmic Baryon Budget of Fukugita et al.

In Fukugita et al. (1998), they present an estimate of the global budget of baryons in all states, with conservative estimates of the uncertainties, based on all relevant information they have been able to marshal. Most of the baryons today are still in the form of ionized gas.

They declare that the sum over their budget, expressed as a fraction of the critical Einstein-de Sitter density, is in the range $0.007 \lesssim \Omega_b \lesssim 0.04$, with a best guess of $\Omega_b = 0.021$ (at Hubble constant 70 km s^{-1} Mpc^{-1}).

It should be noted that observations of the diffuse soft X-ray background suggest that it may have been produced by diffuse cosmic plasma with a much higher average mass density than the estimated in "Cosmic Baryon Budget" (Fukugita et al. 1998). Because Fukugita et al. could not find a theory to explain why there were so many baryons in the void, they unreasonably omitted this fact from their "cosmic baryon budget." Therefore, "the cosmic baryon budget" of Fukugita et al. is not based on all available observations. Important diffuse soft X-ray background observations are unreasonably omitted.

2.2. Estimation from Observations of the Diffuse Soft X-Ray Background

According to Fukugita et al. (1998), observations of the diffuse soft X-ray background (Wang & McCray 1993) indicate it could be produced by diffuse cosmic plasma with a mean mass density of baryons

$$(\Omega_{H\ \mathrm{II}})_{\mathrm{IGM}} = 0.2\zeta^{-1/2}C^{-1/2}h_{70}^{-3/2} \tag{3}$$

where the emissivity parameter ranges from $\zeta = 1$ for solar to $\zeta = 0.1$ for primordial abundances, and the clumping parameter $C \equiv \langle N_e^2\rangle / \langle N_e\rangle^2$ (please refer to 2.6.1. *Warm Plasma in the Voids* in Fukugita et al. 1998).

Numerical estimate of Equation (3) suggests that the cosmic baryon mass density Ω_b can be much larger than value given by the ΛCDM model, if the cosmic plasma is more smoothly distributed than the visible matter. This is consistent with general relativity: if the mass of the universe is more evenly distributed than that of galaxies, then the mass density of the universe would be high (see p.574 in Peebles & Bharat 2003).

2.3. Estimations from Observations of X-Ray and Gravitational Lensing of Galaxy Clusters

In Wu (2000) he presented a combined analysis of mass estimates in the central cores of galaxy clusters from the strong lensing, the X-ray measurements and the universal density profile. A statistical comparison of these three mass estimates reveals that if the masses of 21 galaxy clusters (26 events) are estimated using gravitational lensing and X-ray measurements, statistical comparisons show that the mass discrepancies of all events are well within a factor of 2 (refer to Figure 1 in Wu 2000).

Xue & Wu (2002) further showed, based on Einstein, ROSAT, and ASCA observations, the X-ray centroid of A1689 appears to coincide perfectly with the central cD galaxy. They present an estimation of the projected X-ray mass of A1689 observed with Chandra X-Ray Observatory. Their analyses confirm that there is a discrepancy of a factor 2 between X-ray and lensing mass estimates in the central region (i.e., $r < 0.2$ Mpc). But on large radii, the mass of the X-ray emission gases and the gravitational lensing mass of the cluster essentially are consistent, i.e $M_{\rm lens} \sim M_{\rm xray}$. This means that the distribution of X-ray emitting gas (cosmic plasma) is smoother than that of gravitational lensing matter.

Evidently, X-ray emitting gas is cosmic plasma. Combined observations of the diffuse soft X-ray background reported by Wang & McCray (1993) and observations reported by Wu (2000) and Xue & Wu (2002), it is reasonable to believe that in the universe $\Omega_{\rm lens} \simeq \Omega_m \simeq \Omega_b$. This means that cosmic plasma is a better candidate for dark matter, and rules out the existence of non-baryonic dark matter in cosmological models.

Obviously, the $M_{\rm lens} \sim M_{\rm xray}$ reported by Wu (2000) and Xue & Wu (2002) is more reliable than the estimate of Coma cluster reported by Zwicky (1933, 1937). This means that the high speed dispersion of the Coma cluster cannot be used as evidence for non-baryonic dark matter in the universe (de Swart et al. 2017).

2.4. Estimations from the Planck 2013 Results

The European Space Agency's Planck satellite was launched on 2009 May 14 and has been scanning the microwave and submillimetre sky continuously since 2009 August 12. In 2013 March, ESA and the Planck Collaboration released the initial cosmology products based on the first 15.5 months of Planck data,

In 2014, the Planck Collaboration published Planck's 2013 results. Based on the ΛCDM cosmological model, they derive many cosmological parameter values. Their results are considered standard cosmological parameter values. These standard cosmological parameter values can be found in A&A 571, A1(2014) or A&A 571, A16(2014).

In deriving the baryon mass density, they set its prior range $\Omega_b h^2$ as [0.005–0.1]. Under this assumption, they came up with the best fit result, $\Omega_b h^2 \sim 0.022$. Since their derivation of the Hubble constant is $H_0 \sim 67$ km s^{-1}Mpc $^{-1}$, this means that the mass density of baryons is $\Omega_b \sim 0.049$. Because they deduced a gravitational mass density is $\Omega_m \sim 0.32$, to fill the gap between gravitational mass density and baryon mass density, they introduced non-baryonic cold dark matter Ω_c into their model (see Table 9 and Table 10 in Planck Collaboration 2014a) or (see Table 1 and Table 2 in Planck Collaboration 2014b).

Why did they set the prior range $\Omega_b h^2$ to [0.005–0.1]? Apparently, this is due to their belief that the CMB observed is a relic of early hot cosmic radiation (Peebles & Seager 2000; Peebles 2017). If the prior range $\Omega_b h^2$ is greater than 0.1, the S-Z effect caused by cosmic plasma will severely disrupt the observed CMB perfect blackbody spectrum (Sunyaev & Zeldovich 1980; Zheng 2021).

3. Discussion and Conclusion

Based on the supernova Ia observations, in the ΛCDM model, dark energy ($\Omega_\Lambda \sim 0.70$) and gravitational mass density ($\Omega_M \sim 0.30$) are assumed to exist in the universe (Perlmutter et al. 1999). Currently, gravitational matter is hypothesized to consist of known baryons and hypothesized non-baryonic cold dark matter (Peebles & Bharat 2003; Planck Collaboration 2014a, 2014b).

Observations show that almost all baryons are currently in the state of high temperature ionized gas, forming cosmic plasma. Most astrophysicists believe that CMB is the thermal relic of the early hot universe and if the gravitational mass density ($\Omega_M \sim 0.30$) entirely consisted of cosmic plasma, then the S-Z effect caused by cosmic plasma would severely disrupt the observed CMB perfect blackbody spectrum. Thus, in Planck Collaboration (2014a, 2014b) the prior range of cosmic plasma mass density $\Omega_b h^2$ is set to be [0.005–0.1]. Under this assumption, they came up with the best fit for $\Omega_b h^2 \sim 0.022$. This means that the mass density of baryons is $\Omega_b \sim 0.049$.

In order to fill the gap between gravitational mass density and cosmic plasma mass density, non-baryonic dark matter is introduced into the ΛCDM model. But no astrophysicist knows what non-baryonic dark matter is. It is simply a hypothetical concept.

The hypothesis that the observed CMB is a relic of thermal radiation from the early hot universe is just an unreasonable conjecture. Because this hypothesis requires that after the formation of the "last scattering plane," the universe should be free of cosmic plasma (Peebles 2017). This hypothetical requirement clearly contradicts the real universe. Since most astrophysicists insist that the observed CMB is a thermal radiation relic of the early hot universe and attempt to reduce the influence of cosmic plasma by limiting the density of baryons, this has led to the "dark matter mystery" persisting for nearly a century (de Swart et al. 2017).

Gravitational lensing and X-ray observations of galaxy clusters suggest that the gravitational mass density may entirely consist of cosmic plasma. This means that large amounts of cosmic plasma and the observed perfect blackbody spectrum of CMB can harmoniously coexist in the real universe. This fact does not currently have a satisfactory theory to explain.

Therefore, to solve the "dark matter mystery," the crux of the matter is to find a theory as to why large amounts of cosmic plasma and the observed perfect blackbody spectrum of CMB can coexist harmoniously in the real universe.

One possible and intriguing theory is that the observed CMB is the result of a partial thermal equilibrium between cosmic radiation and cosmic plasma. In this case, the density of cosmic plasma Ω_b can be as large as the gravitational mass density Ω_m. As a result, large amounts of cosmic plasma and the observed CMB's perfect blackbody spectrum can harmoniously coexist in the real universe without the introduction of mysterious non-heavy dark matter.

By the way, flat rotation curves in galaxies are also considered evidence for the existence of non-baryonic dark matter. In Jalocha et al. (2008), they reported that a global mass distribution in spiral galaxy NGC 4736 (Messier 94) agrees perfectly with the high-resolution flat rotation curve of the galaxy without non-baryon dark matter. The key is that they used an iterative approach to more rationally reconstruct the mass distribution in the spiral galaxy.

4. Conclusion

If astrophysicists could abandon the idea that the observed CMB is a relic of the early hot universe and accept that the observed CMB is the result of a partial thermal equilibrium between cosmic radiation and cosmic plasma, then the "dark matter mystery" would be solved. Gravitational mass may almost entirely consist of cosmic plasma. There is no need to introduce non-baryonic dark matter into cosmological models.

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