Discrepancy in Velocity Dispersion and Rotation Curve of Galaxy

Mitali

Patiala Institute of Engineering and Technology for Women, Punjab Technical University, Patiala 147004, India
Email: mitalie100@gmail.com

Abstract

The difference between observed and expected values of velocity discrepancy in mid 1930s gave rise to the problem of missing mass in galaxies. Further extra mass calculated from the gravitational lensing effect also supported strongly in favor of missing mass, called dark matter. However, this non-baryonic matter has not been detected directly. Meanwhile, effect of gravitational waves energy from galaxy and result of its angular momentum on rotational curve of spiral arms in outskirts of galaxy is not taken into consideration. Here, it is discussed how gravity waves energy can eliminate the necessity of dark matter and can explain the observational facts which are thought to be purely effect of dark matter.

Keywords: dark matter, galaxy rotation curves, velocity dispersion, gravitational lensing, gravitational waves

1 INTRODUCTION

The precision detection of gravitational waves by LIGO team has cleared all the clouds over last prediction of general relativity (Abbott et al. 2016). In this paper, author wish to suggest a new approach to explain the discrepancy between observed and calculated velocity and rotation curve with the help of gravitational waves. It is an observational fact since 1930's that the total amount of matter (baryonic) cannot be accounted for the explanation of rotational curve (Roos. 2003).

From calculations, baryonic matters do not add up to the expected matter required to keep stars in orbit at the edge of galaxy. Something is accounting for addition centripetal force to keep stars at the edge of galaxy in orbit. Hence, a new form of matter was hypothesized, Dark Matter, which could be fitted into galaxy model to match with the data. Since then a lot of observed factors are considered to be an effect of dark matter. However, it is to be noted that till now no concrete direct evidence of any such matter (non-baryonic particle) has been found. Here, author wish to present an explanation for this observed discrepancy without using dark matter with the help of gravitational waves energy produced within the galaxy.

While calculating for extra resultant velocity only thing that was taken into consideration was keplerian orbit where velocity should fall with distance. Now, assuming a spiral galaxy 'A' with orbital velocity, v and distance from galaxy center, r (Choudhuri. 2010). So, relation between v and r can be stated as

$$v \propto 1/r$$

The following graph Figure 1 shows change in velocity with distance for galaxy A.

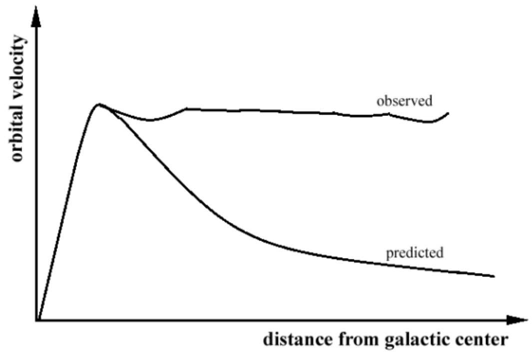

Figure 1 Rotation curve of galaxy A

Here, effect of gravitational waves and role of angular momentum of gravity waves on stars system at the edge of galaxy is not taken into consideration.

2 ENERGY OF GRAVITATIONAL WAVES INSIDE GALAXY

Like any other waveform, gravitational waves superimpose on each other thereby increasing the energy carried by it. Inside galaxy, energy does not depend only on centralized black hole but also on other massive bodies distributed throughout the galaxy. This results in increment of energy in the waveform (even when amplitude is very low). If we take luminous mass distribution, gravitational waves energy inside the galaxy will increase with distance as more mass will add up. This in turn will produce high energy gravitational waves (by superimposing). The energy density of these waves are represented by

$$\rho_{gw} = \frac{1}{32\pi G_N}\left\langle h^2 \right\rangle$$

Here $\left\langle h^2 \right\rangle$ is spatial averaging over several wavelengths (Schutz. 2009; Roos. 2003; Liddle, 2003). Also, it should be noted that these waves carries with them angular momentum which could play a considerable role in shaping spiral arms and its rotation around galactic center. At the edge of galaxy, energy will be maximum, and then drop off by a factor of inverse square of distance from linearized equation (Matarrese, 2011).

$$\rho \propto 1/r^2$$

Hence, the graph of gravitational waves energy for galaxy A should look like Figure 2.

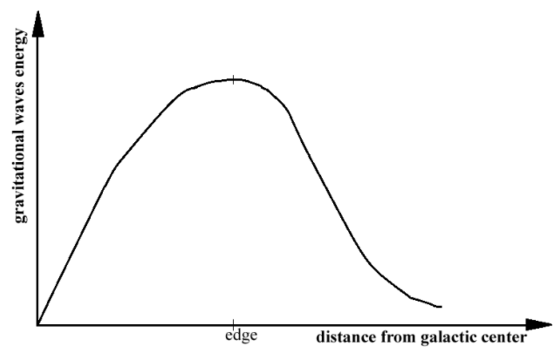

Figure 2 Graph showing gravitational waves energy inside and outside galaxy A

2.1 Combine effect of baryonic matter and gravity waves

Now, we apply the combined effect of gravitational waves as well as baryonic matter on stars system in the outskirts of galaxy simultaneously. Our assumed galaxy ‘A’ will have a graph curve as Figure 3. Here curve (A) represent gravity waves which increases from center to the edge of galaxy and then fall off. Curve (B) denotes velocity due to baryonic matter which falls off as it approaches the edge of galaxy. Curve (C) represents the combined effect of both (A) and (B) which is similar to the observed velocity which is nearly constant. Since gravity waves travels at light speed, velocity to distance graph will remain constant.

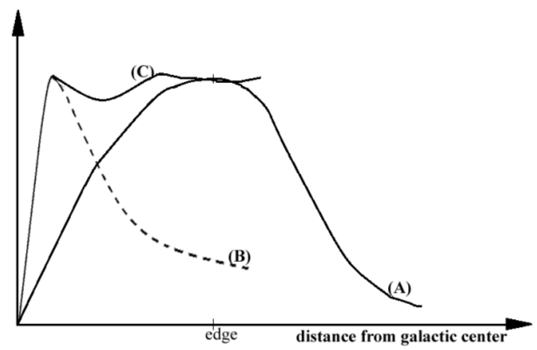

Figure 3 Combined effects of gravity waves (A) and velocity curve (B) obtained from baryonic matter distribution.

Gravitational waves are spread out in galaxy rather than accumulating at the center. This can explain the effect of missing mass being so evenly distributed inside galaxy. Since, energy in these waves fall off as inverse square of distance, its effect on outskirts of the galaxy can also be studied.

2.2 Estimating energy from lensing effect

We know that gravity waves are the oscillation of fabric of space-time itself and that they interact least with any other form of matter (Roos. 2003; Liddle. 2003). Since, highest accumulation of energy from waves will be at the edge of galaxy; commonly observed feature of gravitational lensing can be used in this context to figure out the energy and thus amplitude of waves itself. Lensing formula for bending light by galaxy (Liddle. 2003; Roos. 2003):

$$\theta = \frac{4MG}{rc^2} \text{ or } \theta = (const.)\, M/r$$

From here, we can calculate mass required to bend the light. Also, we can calculate the baryonic mass of galaxy (by luminosity distribution). Now, let the difference between mass calculated from both method be ΔM . Usually, this mass is accounted for dark matter presence but we can use this mass to calculate the energy of gravity waves at the edge of galaxy A by mass-energy equivalence. Hence by obtaining energy from this method, we can now know the amplitude of gravitational waves produced by galaxy. Amplitude of the oscillation is very small even when gravitational waves carries huge amount of energy so, its values will be far less as compared to energy obtained.

3 DISCUSSION

Gravitational waves (produced by all massive objects inside the galaxy) are largely ignored when it comes to calculate the velocity dispersion. Also, when referring to uniform rotation of the spiral arms of galaxy, angular momentum due to gravity waves are ignored. This results in discrepancy between observed and calculated velocities of stars in the outskirts of galaxy. The series of ‘acoustic peaks’ in cosmic microwave background (with regular periodic intervals) can be used as the effect of gravity waves energy travelling at light speed.

4 CONCLUSION

When we take into account non luminous matter (black holes, brown dwarfs etc.) and energy carried by gravity waves towards the edge of galaxy along with luminous mass we find that the need of dark matter is no longer required. Also, it is to be noted that gravity waves are hypothesized to have a carrier called ‘graviton’ (not detected yet). It is probable that most of instruments for the direct detection of dark matter are unintentionally looking for this graviton particle. Hereby, author wish to call for further investigation regarding role of gravity waves energy for keeping stars in orbit at the edge of galaxy.

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