A new method to detect gravitational waves

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Abstract

In this paper, a new method for detecting the gravitational waves designed on the basis that the viscosity coefficient of the dark matter fluid may affect the gravitational constant. In this method, the devices that measure the gravitational constant are mainly used to measure the change of the gravitational constant. When gravitational waves pass over, it helps to form an interaction between the sun and the dark matter fluid by means of gravitational waves, thereby transferring part of the sun's heat to the dark matter fluid. Therefore, the increase in this part of the heat will lead to an increase in the temperature of the dark matter fluid. The increase in the temperature of the dark matter fluid leads to an increase in the viscosity coefficient of the dark matter fluid. The increase of the viscosity coefficient of the dark matter fluid directly leads to the increase of the gravitational constant. Since 2015, we have been able to detect the gravitational waves reaching the earth through LIGO and other devices. Therefore, this paper compares the measurement data of the gravitational constant of HUST-18 since 2015 with the gravitational wave data obtained by LIGO. It was found that the measured gravitational constants tend to be higher in the years when gravitational waves were detected. In 2016, when no gravitational waves were detected, the measured gravitational constant was significantly lower.

1 Introduction

I have mentioned the relationship between the viscosity coefficient of dark matter fluid and the gravitational constant in the previous article [1]. This means that if we can measure the change in the viscosity coefficient, then we can obtain the change in the gravitational constant. How the viscosity coefficient of the dark matter fluid changes, we have no concrete and precise evidence. However, we can know from the existing knowledge of thermodynamics that for gases, if the temperature changes, the viscosity coefficient will also change. Generally, the higher the temperature, the higher the viscosity coefficient. If the temperature change is small, we can use a linear approximation to deal with such problems. In this way, we can conclude that if the temperature of the dark matter fluid increases, the viscosity coefficient will also increase linearly, which will lead to a linear increase in the gravitational constant.

However, it is currently known that dark matter only participates in gravitational interactions and does not participate in electromagnetic interactions. For celestial bodies like the sun, although the temperature is very high, the increase in the temperature of the sun is mainly due to electromagnetic interactions. Therefore, it is believed that the extremely high temperature of the sun is not directly transmitted to the dark matter fluid through electromagnetic interactions.

But since the dark matter fluid participates in the gravitational interaction, if there is a gravitational interaction between the sun and the dark matter fluid, it is possible to transfer part of the temperature of the sun to the dark matter fluid, thereby increasing the temperature of the dark matter fluid.

2 Estimation of the change of viscosity coefficient of dark matter fluid

Since dark matter has nothing to do with electromagnetic interactions, the heating inside the sun is mainly caused by electromagnetic interactions, which makes it impossible for the ultra-high temperature of the sun to be directly transmitted to dark matter. But if there are gravitational waves, it will cause an interaction between the sun and the dark matter fluid, so that the energy of the sun is transferred to the dark matter fluid with the help of gravitational waves. Taking into account the first law of thermodynamics, the temperature will be transferred from the relatively hot sun to the relatively cold dark matter, causing the temperature of the dark matter fluid to rise.

It is assumed here that gravitational waves pass over, causing the energy of the dark matter fluid in the solar system to rise by ΔE.

If the energy of the gravitational waves we consider is very small relative to the energy of solar radiation, we can use a linear approximation to deal with it. Under the condition of linear approximation, the rise of dark matter fluid energy should be proportional to the energy transmitted by gravitational waves.

The ratio of the energy density of the gravitational waves transmitted in this way to the energy density radiated from a certain location in the solar system, and the ratio of the increase in the energy of the dark matter fluid to the internal energy E of matter in the entire solar system (including the total internal energy of all dark matter and matter) is equal.

So we can calculate

$$\Delta E = \frac{E \cdot W_G}{W_S}$$

To meet the requirements of a linear approximation, it is necessary to

$$W_G \ll W_S$$

where E is the internal energy of the solar system including dark matter and visible matter, W_G

is the energy density of gravitational waves, and W_S is the energy density radiated from the sun.

Then we assume that this part of the rise in energy is all converted into an increase in the temperature of the dark matter fluid. This allows us to calculate the magnitude of the dark matter temperature rise as

$$\Delta T = \frac{\Delta E}{C_v}$$

where C_v is the heat capacity of the dark matter fluid.

Of course, this temperature increase is also very small, so we can also use a linear approximation to solve the problem.

under the condition of linear approximation. The change in viscosity coefficient is also proportional to temperature. The gravitational constant is also proportional to the change of the viscosity coefficient, so we can formulate the change of the gravitational constant caused by the arrival of gravitational waves as:

$$\Delta G = k\frac{\Delta E}{C_v} = k\frac{E \cdot W_G}{W_S C_v}$$

where k is a constant. G is the gravitational constant.

If we assume that the current solar system-wide dark matter fluid obeys the laws of thermodynamics we now know. Then the temperature of the dark matter fluid is proportional to the internal energy E of the dark matter fluid. That is to say, we can express the temperature of dark matter in the solar system as

$$T = \frac{E}{C_v}$$

Therefore, after considering the relationship between the gravitational constant and the viscosity coefficient of the dark matter fluid, we have:

$$G = k\frac{E}{C_v}$$

So we can get

$$\frac{\Delta G}{G} = \frac{W_G}{W_S}$$

or

$$\Delta G = G\frac{W_G}{W_S}$$

In 2015, the gravitational waves detected by LIGO were gravitational waves emitted by the merger of two black holes, LIGO GW150914 and GW151226 [2]. The initial masses of these two black holes are $36M_{\odot}$ and $29M_{\odot}$ respectively, and the final mass of the merged black hole is $62 M_{\odot}$. The lost mass of $E_W = 3.0M_{\odot}c^2$ is radiated by gravitational waves. Before and after the merger of the two black holes, the distance from the earth reaches R = 1.4 billion light-years.

According to the attenuation of spherical waves according to the law of inverse square, we can calculate the energy radiated to the earth as:

$$E_G = \frac{E_W}{4\pi R^2} = \frac{3 \times 2 \times 10^{30} \times (3 \times 10^8)^2}{4\pi \times (9.46 \times 10^{15} \times 1.4 \times 10^9)^2} \approx 2.45 \times 10^{-4}(J \cdot m^{-2})$$

In addition, the duration of the gravitational wave detected by LIGO is $200ms$[3], so the energy density can be calculated as

$$W_G \approx 1.22 \times 10^{-3}(J \cdot m^{-2}s^{-1})$$

Now the energy density that sun radiates to the earth (Solar constant) is

$$W_S = 1366(J \cdot m^{-2}s^{-1})$$

This can be calculated

$$\Delta G \approx 8.93 \times 10^{-7}G$$

The highest precision HUST-18 currently measuring the gravitational constant is about $10ppm$ (10^{-5})[4]

From the calculation results, it seems that the change of the gravitational constant caused by the energy density of gravitational waves is not enough to cause the abnormal response of the instrument. But we can notice that the above calculation treats the radiation of gravitational waves as an isotropic spherical wave.

In fact, due to the obvious directionality when black holes merge, the propagation of gravitational waves is also directional. This results in a very strong gravitational wave signal being received in one direction, but very difficult to receive in the other direction. Otherwise, if all the gravitational waves in the universe are such isotropic spherical waves, we should be able to receive a large number of gravitational wave signals every day.

Therefore, if the gravitational waves generated by the merger of the two black holes GW150914 and GW151226 are exactly in the direction of the Earth, and the radiation area of the gravitational waves is only 1% of the entire spherical surface, then we can estimate that the energy density of the gravitational waves reaching the Earth causes the gravitational constant changing will reach

$$\Delta G \approx 8.93 \times 10^{-5} G$$

This is another 10 times greater than the measurement accuracy of HUST-18. So it should be measurable.

3 Influence of strong gravitational waves on the measurement of gravitational constants

The first measurement of gravitational waves from a black hole merger between LIGO and VIRGO was on September 14, 2015. Later, gravitational waves were detected three times on December 26, 2015, January 4, 2017, and August 14, 2017. Another gravitational wave produced by the merger of two neutron stars was detected on August 17, 2017.

It can be seen from this that 2016 was a relatively weak year for gravitational waves. So theory predicts that the gravitational constant measured in that year will be smaller.

There was no suitable device to detect gravitational waves until September 2015. After 2015, only HUST-18 has been measuring the gravitational constant in the world, and the duration is exactly from 2014 to the end of 2017. And the measurement accuracy of HUST-18 is very high, so this measurement data has a good reference control effect.

August 2017 was a period of relatively active gravitational waves. Therefore, the theoretical prediction of the measured gravitational constant will be too large.

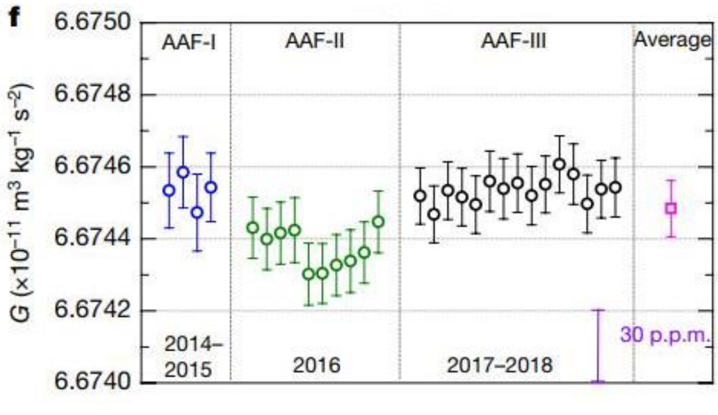

Figure 1. The results of Hust-18

Picture quoted from: Li, Q., Xue, C., Liu, J. et al. Measurements of the gravitational constant using two independent methods. Nature 560, 582–588 (2018).

It can be seen from Figure 1. that the gravitational constant measured in 2016 (April to June) is obviously small. According to the results predicted by the paper [1], the gravitational constant measured in 2017 is smaller than the gravitational constant measured by AAF-I in January 2015, but larger than that of AAF-II. However, from the results of HUST-18, the average value of the gravitational constant measured by AAF-III is obviously larger in January 2015.

References

[1] Cheng, Z. The Reason for the Change in the Gravitational Constant. https://vixra.org/abs/2205.0072

[2] Abbott BP, Abbott R, Abbott TD & et al. LIGO Scientific Collaboration and Virgo Collaboration. Observation of Gravitational Waves from a Binary Black Hole Merger. Phys Rev Lett. 2016 Feb 12;116(6):061102.

[3] LIGO. GW150914 Factsheet. https://dcc-llo.ligo.org/public/0123/G1600220/010/GW150914-FactSheet.pdf

[4] Li, Q., Xue, C., Liu, J. *et al.* Measurements of the gravitational constant using two independent methods. *Nature* **560,** 582–588 (2018).