Estimation of Redshift Effect of Neutrino Photon Interaction and Discussion on the New Neutrino Detection Device

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Abstract: This paper assumes that the red shift of the galaxies' spectrum is due to the interaction of photons with neutrinos in the universe space. Using the available data, a rough estimate of the amount of redshift that this effect can produce is obtained, yielding an order of magnitude for the neutrino photon interaction to produce a redshift effect. On this basis, this paper designs two devices that can be used to detect the number of neutrinos through this effect.

Key words: neutrino; photon; interaction; red shift

1 Introductions

As I mentioned in the previous paper [11], photons may interact with neutrinos. Since this interaction does not rely on large mass intermediate bosons, the probability of this interaction should be large, helping us to detect neutrinos using relatively small devices.

As for the study of the interaction between photons and neutrinos in the framework of standard models, there may be rarely seen, but there are still some papers discussing the possible interactions between photons and neutrinos. [1~8] For example, Bandyopadhyay studied some of the interactions between photons and neutrinos in the 1960s through the analysis of standard models [6, 7].

These papers have not been cited many times, and it can be seen that they have not attracted people's attention.

Much different from the above studies, I have established a new model of neutrinos here, which is a good description of the difference between the interaction between photons and neutrinos and other weak interactions. Of course, whether the new theory can be established or not requires the verification and support of more experimental data.

2 Known facts

The interaction between neutrinos and photons is also based on the following facts:

1. The existing theoretical analysis shows that neutrinos and photons can interact. It is generally believed that after the boson Z^0 releases a neutrino, the neutrino can release a photon during the flight. The process by which neutrinos

release photons does not require intermediate bosons.

2. Neutrino oscillation. We can of course use the superposition of the three mass eigenstates of neutrinos to illustrate neutrino oscillations. However, the hypothesis that such neutrinos have static mass is contradictory to the special relativity theory. There is currently not enough evidence to prove that there is any problem with the special relativity theory, and there is not enough evidence to prove that the speed of neutrinos is lower than the speed of light or higher than the speed of light. Therefore, I would rather use the dispersion phenomenon of neutrinos to explain the oscillation of neutrinos [11]. In view of the fact that neutrinos do not interact with other substances, one reason for the neutrino's dispersion is that neutrinos interact with photons.

3. The number of neutrinos in the universe. According to the standard model theory, neutrinos do not interact electromagnetically with other substances, and the cross-section of weak interactions is very small, so neutrinos are difficult to disappear once they are produced. Another fact we know is that there are many reactions in the universe that can continuously produce a large number of neutrinos. This means that the neutrinos in the universe will accumulate more and more until the entire universe is completely filled with neutrinos. However, the neutrinos we can detect now mainly come from nuclear fusion inside the sun and neutrinos produced by the cosmic high-energy particles reacting in the atmosphere. The number of neutrinos that originate in other parts of the universe is very small. This shows that neutrinos may not be as stable as we think, and they are easy to produce and easily disappear through some kind of interaction.

4. Red shift of the galaxies' spectrum. According to the interpretation of the existing big bang theory, the reason for the red shift of the galaxy's spectrum is that these galaxies are accelerating away from the earth. Due to the Doppler effect of light waves or spatial expansion, the observation of these light frequencies on the Earth reveals a red shift. However, there are still many unsatisfactory points in these explanations. For example, according to Hubble's law, the farther away from the Earth, the faster the planet leaves. The galaxies that have been observed to be about 14 billion light-years away from Earth are now close to the speed of light. If it is a little further, or if it accelerate for many years, isn't it faster than the speed of light? Believe that the farthest galaxy we can observe now should not be the edge of the universe.

Even in the case of a curved universe, the galaxies that are farther away from the Earth should not appear to move away from the faster. This is like the effect of the diffusion motion of an object on a sphere.

Therefore, other models that explain the phenomenon of redshift of this galaxy spectrum are also very instructive and important.

In the previous article, I thought that this redshift should be caused by the light emitted by the galaxies interacting with the neutrinos in the universe, resulting in the loss of energy of the photons and redshift. This is a good explanation of why the farther away from the Earth, the greater the redshift.

So it can be seen that interaction between photons and neutrinos has been gotten a certain degree of recognition.

3 Estimating the effect of neutrinos on photon spectrum by galaxies redshift

According to some of the known galaxy redshift data, for example, here the galaxy A1689-zD1 is taken as an example for rough estimation.

According to the data given in paper [9], the galaxies A1689-zD1 have a redshift value of z=7.5, so they can be converted into frequency changes:

$$\frac{f}{f_0} = 8.5$$

Where f is the frequency of the galaxies' rays. And f_0 is the frequency after redshift. Where f_0 corresponds to a wavelength of approximately 1000 nm, that is $3 \times 10^{14} s^{-1}$

From this, we can calculate the frequency of the galactic rays.

$$\mathrm{f} = 2.55 \times 10^{15} s^{-1}$$

The galaxy is about 13 billion light years away from the Earth and is converted into meters.

$$\mathrm{d} = 1.23 \times 10^{26} m$$

So the frequency change per meter is about $\Delta \mathrm{f} = 1.8 \times 10^{-11} s^{-1} m^{-1}$

If converted to wavelength, the change in wavelength per meter is approximately $\Delta\lambda = 7 \times 10^{-24} nm/m$

Then consider the neutrino density of the area where the light passing through.

First, we can suppose that the neutrinos have the highest density near the star, and assume that the number of solar neutrinos per cubic meter of the earth is close to the average of the neutrino density in the entire solar system. The nearest known galaxies to the solar system are 4 light years and can also be used as an average.

Considering that the volume of the solar system is about $10^{39} m^3 3$, the spatial volume including the Solar system and the Proxima Centauri is about $10^{49} m^3$

This can estimate the density of neutrinos in the outer space of the solar system is about $\mathrm{n} \times 10^{-10} m^{-3}$, That is to say, the neutrino density on the earth is 10^{10} times the density of the neutrinos in this part of the universe.。

Since the solar system is located at the edge of the Milky Way Galaxy, the concentration of neutrinos in this part of the space is much smaller than the concentration of neutrinos in the center of the Milky Way Galaxy. However, the neutrino concentration in this part of the space is greater than the neutrino concentration in the cosmic space between the galaxies. Therefore, the neutrino concentration of this part of the space can be taken as the average of the neutrino concentration of the entire space. Of course, the error handled in this way is relatively large, but in the absence of information such as the concentration of neutrinos in the center of the Milky Way Galaxy and the average distance of the galaxies, such valuations still have some value.

Consider that the experimental devices are measured on Earth. The number of neutrinos per unit volume on Earth is 10^{10} times the average number of the universe, so if we set the distance of interaction between neutrinos and photons to 1 meter in the experimental devices, we can simply estimate that the measured photon frequency change is approximately $0.18 s^{-1}/m$, or the photon wavelength change is approximately $7 \times 10^{-14} nm/\mathrm{m}$

From such estimates, existing devices may be difficult to measure such subtle wavelength variations. However, for frequency changes, measurements should still be possible with very sensitive equipment. Two devices can be used to detect such changes in wavelength or frequency. The interference of light is used to measure the change of wavelength. The Mössbauer effect is used to measure changes in frequency.

4 Using the interference effect of light to detect the interactions between photons and neutrinos

Measurements of small variations in light frequency can be made by interference fringes of the light. The measuring device shown in Fig. 1 is given here.

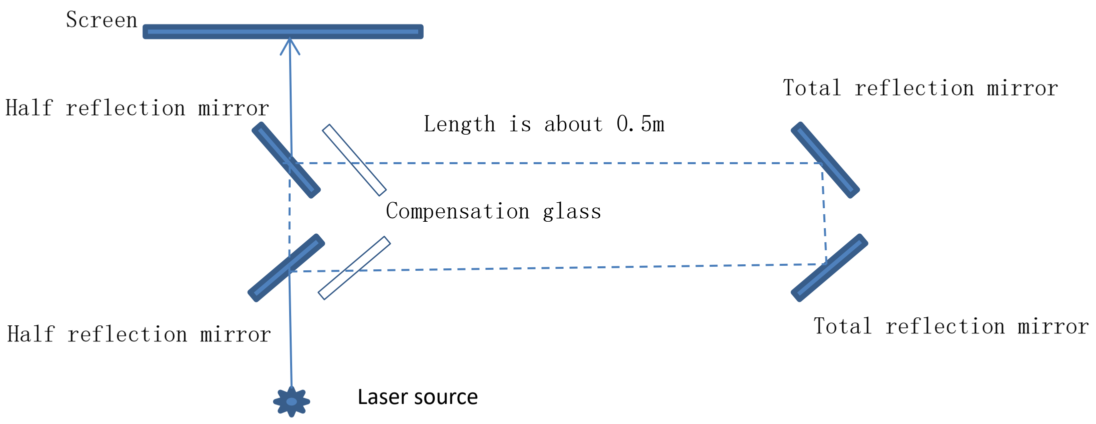

Figure 1. Measurement of photon neutrino interactions using light interference effects

In the device of Fig. 1, the light from the laser source passes through the half mirror and is split into two paths, and the path continues to run in a straight line, illuminating the screen. The other road is then 90 degrees refracted and then reflected back through the two total reflection mirrors on the right. It will reflect to the screen through the second half mirror in the end. Since the optical path differences of the two beams are different, an interference pattern is formed on the screen. Once one of the rays is affected by the neutrino, the frequency changes slightly, and it can be displayed by the interference fringe on the screen.

The device shown in Figure 1 is basically identical in principle to the Michelson interferometer. According to the accuracy of the wavelength change that can be measured by the current Michelson interferometer is about 10^{-2} nm, the interaction between the solar neutrinos and the photons may be insufficiently accurate by using the device. However, if the concentration of neutrinos can be increased by 10^{10} times, the device should be able to measure the apparent wavelength change effect. For example, next to the reactor, the concentration of neutrinos should be close to this order of magnitude.

5 Using the Mössbauer effect to detect the interaction between photons and neutrinos

The use of light interference effects is generally applicable to visible light, while the frequency of visible light is relatively low, resulting in insufficient accuracy of the entire experimental results. The Mössbauer effect uses gamma rays, which are very energetic, so that the change in photon frequency can be measured with high precision. For example, the accuracy of ^{107}Ag can reach $\frac{\Delta E}{E}\sim 10^{-22}$, so that the measurement demand of $\frac{\Delta f}{f} = 10^{-16}$ frequency variation can be satisfied.

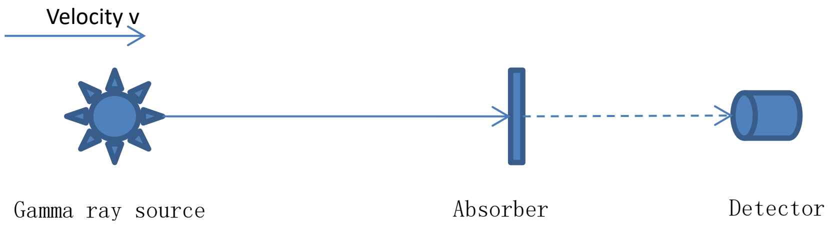

Figure 2 Using the Mossbauer effect to detect photon neutrino interactions

Figure 2 shows that the distance between the gamma ray source and the resonant absorbing material can be adjusted according to the requirements of experimental precision. The longer the distance, the higher the accuracy of the experiment obtained.

In fact, there have been experimental results using the Mössbauer effect to measure the redshift of gravitation. Moreover, the magnitude of the change in the frequency of the light measured by the experiment is similar to the experimental accuracy requirement of this experiment. It proves that the Mössbauer effect is sufficient to meet the need to obtain sufficiently accurate results.

In addition, from the experimental data given in paper [10], whether the radioactive source is placed at the top of the tower or at the bottom of the tower, the measured gamma ray is red-shifted, and according to theoretical prediction, the gamma ray emitted from the top of the tower should be measured to the blue shift at the bottom of the tower. It explains that there is a large systematic error. No specific explanation is given in [10].

Here we consider the interaction that gamma rays may have with neutrino-photon interactions. According to the data in [10], the average redshift frequency can be calculated as

$$\Delta \mathrm{f} = -17.6 \times \frac{3.6 \times 10^{18}}{10^{15}} = -6.3 \times 10^{4} Hz$$

In the above data, the negative sign indicates a red shift.

In this paper, according to the frequency shift data estimated by the redshift of the galaxy, the frequency per meter is about 0.18 Hz for the light with a frequency of about 10^{14} Hz, and the distance between the source and the absorber in the experimental device is 22.5 m. Considering that the gamma ray frequency in the experiment is much higher, the frequency shift is also scaled up. In this way, it can be estimated that the influence of the neutrino on the gamma ray frequency shift is about $4.5 \times 10^{4} Hz$, which is consistent with the experimental value provided by the paper [10]. It may be explained that the systematic errors involved in the paper [10] are at least partly due to the interaction of photons and neutrinos. If you need to verify this, you can consider installing the device in a place with a high concentration of neutrinos and then measuring it. You should be able to measure a larger redshift value.

6 Conclusions

This article explores how to use the interaction of photons and neutrinos to detect neutrinos. If the conclusions of this paper are experimentally verified, it will be able to provide a new method to detect neutrinos, and also help to promote the miniaturization of neutrino detection equipment and the improvement of detection accuracy.

From the existing theoretical analysis and experimental data, the interaction between neutrinos and photons still has many theoretical and experimental supports. There are still many uncertainties in the scattering cross section of neutrinos interacting with photons. Is this section too small, and ultimately no use value? In this paper, we use the experimental data of cosmic galaxies redshift and the Mössbauer Effect that was used to verify the gravitational redshift. It is believed that the reaction cross section of neutrinos interacting with photons may be large enough to detect using the Mössbauer Effect.

However, there are still some shortcomings in the analysis of this paper. Mainly in the following aspects:

1. Due to the lack of more accurate data, the error of the estimation of the redshift data of the cosmic galaxies is relatively large, so the conclusions obtained may require more experiments to verify and correct.

2. Using the existing data of Mossbauer Effect that was used to detect the gravitational redshift, although the results are consistent with the prediction, but limited to the obtained data, it is difficult to exclude other factors for the gamma ray redshift Impact. For example, Compton scattering of gamma rays may also cause redshift. Therefore, further experiments may be needed to resolve whether these redshift phenomena are caused by Compton scattering or by interaction of neutrinos with photons.

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Appendix: Chinese Version

中微子光子相互作用产生红移效应估算及探测装置的探讨

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摘要：本文假设星系光谱的红移是由于光子与宇宙中的中微子相互作用而产生效应。利用已有的数据，对这种效应可以产生的红移量进行粗略的估算，得出中微子光子相互作用可以产生红移效应的数量级。在此基础上，本文设计了两种装置可以用来通过这一效应探测中微子的数量。

关键词：中微子；光子；相互作用；红移

1 导言

我在上一篇文章中提到[11]，光子可能与中微子产生相互作用。由于这种相互作用不依赖能量巨大的中间玻色子，因此这种相互作用的产生的概率应该会比较大，有助于我们使用比较小型的设备来对中微子进行探测。

至于在标准模型等框架下对光子与中微子之间相互作用的研究，也可以在一些文献中零散地虽然数量不多，但以往还是有一些文章探讨过光子与中微子可能的相互作用[1~8]。比如 Bandyopadhyay 在上个世纪六十年代通过对标准模型的分析，对光子与中微子相互作用的一些研究[6,7]。

这些文献被引用的次数都不多，可以看出并没有引起人们的重视。

与上述研究不太相同的是，我这里建立了一个新的中微子的模型，对光子与中微子之间相互作用同其他弱相互作用之间的区别有比较好的说明。当然究竟新的理论能否成立还是需要实验数据的验证和支持。

2 已知的事实

有关中微子和光子之间的相互作用也是基于如下的一些事实：

1、 已有的理论分析结果表明中微子和光子是可以产生相互作用的。一般认为在中间玻色子 Z^0 释放出一个中微子之后，中微子在飞行的过程中，又可以释放出一个光子。而中微子释放光子的过程是不需要经过中间玻色子的。

2、中微子振荡。我们当然可以用中微子的三种质量本征态的叠加来说明中微子振荡。然而这种中微子有静止质量的假设又是跟狭义相对论有矛盾的。目前还没有足够的证据证明狭义相对论存在任何问题，另外也没有足够的证据证明中微子的速度低于光速或者高于光速。因此我宁愿用中微子的色散现象来解释中微子的振荡【11】。鉴于中微子与其他的物质不会产生电磁相互作用，导致中微子出现色散的一个原因可能就是中微子与光子产生了相互作用。

3、宇宙中的中微子数量。按照标准模型理论，中微子不与其他物质产生电磁相互作用，而弱相互作用的反应截面又非常小，因此中微子一旦产生就很难消失。另一个我们已知的事实就是宇宙中又存在很多反应可以不断产生大量的中微子。这意味着宇宙中的中微子会累积的越来越多，直至整个宇宙完全被中微子充满。然而我们现在所能够探测到的中微子主要来自太阳内部的核聚变以及宇宙高能粒子在大气中反应产生的中微子。而产生于宇宙其他地方的中微子，达到地球的数量则非常少。这说明中微子也许并不像我们想象的那样稳定，很容易产生也很容易通过某种相互作用而消失。

4、星系光谱的红移。按照已有大爆炸理论的解释，造成星系光谱红移的原因是由于这些星系在加速远离地球。由于光波的多普勒效应或者空间膨胀，导致地球上观察这些光线频率会发现出现红移的现象。然而这些解释还是存在很多令人不满意的地方的。比如按照哈勃定律，离地球越远的星系，离开地球的速度越快。现在已经观察到的离地球大约 140 亿光年的星系远离地球的速度已经接近光速了。如果再远一点，或者再过很多年加速，其速度岂不是要超过光速？相信我们现在所能够观察到的最远星系应该不会就是宇宙的边缘。

而即便按照弯曲的宇宙假设，离开地球越远的星系也不应该出现远离速度越快的现象。这就如同在一个球面上物体的扩散运动效果是一样的。

因此，对这种星系光谱红移的现象进行解释的其他模型也是很有启发性的，同时也是很重要的。

在上一篇文章中，我认为这种红移应该是星系发出的光线与宇宙中的中微子产生了相互作用从而导致光子的能量损失，出现红移现象。这能够很好地解释为何离地球越远，红移幅度越大的原因。

由此可见，光子与中微子能够产生相互作用还是得到一定程度上的认可的。

3 通过星系红移估算中微子对光子频谱的影响

现在已知的一些星系红移数据还是比较多的。这里以星系 A1689-zD1 为例来进行粗略估算。

按照文献【9】给出的数据，星系 A1689-zD1 红移值 z=7.5，因此可以换算成频率的变化：

$$\frac{f}{f_0} = 8.5$$

其中 f 为星系光线的频率。而 f_0 为红移以后的频率。其中 f_0 对应波长大约 1000nm，即$3 \times 10^{14} s^{-1}$

由此可以计算出星系发出光线频率为：

$$\mathrm{f} = 2.55 \times 10^{15} s^{-1}$$

该星系距离地球大约 130 亿光年，换算成米：

$$\mathrm{d} = 1.23 \times 10^{26} m$$

因此每米的频率变化大约为：$\Delta \mathrm{f} = 1.8 \times 10^{-11} s^{-1} m^{-1}$

如果是换算成波长计算，则每米波长的变化大约为

$$\Delta\lambda = 7 \times 10^{-24} nm/m$$

然后再考虑该星系发出的光线经过区域的中微子密度。首先假设中微子在恒星附近的密度最高，同时假设达到地球每立方米的太阳中微子数量 n 接近整个太阳系中微子密度的平均数。目前已知的离太阳系最近的星系为 4 光年，也可以作为一个平均数。

考虑太阳系的体积大约为$10^{39} m^3$，包括太阳系和比邻星的空间体积大约为$10^{49} m^3$

这样可以估算出太阳系外部宇宙空间中微子的密度大约为$\mathrm{n} \times 10^{-10} m^{-3}$，也就是说地球上中微子密度是这部分宇宙空间中微子密度的 10^{10} 倍。

由于太阳系位于银河系的边沿，这部分空间的中微子浓度远远小于银河系中心位置的中微子浓度。不过这部分空间的中微子浓度又大于星系之间的宇宙空间中微子浓度。因此可以将这部分空间的中微子浓度作为整个宇宙空间的中微子浓度的平均值。当然这样处理的误差是比较大的，不过在我们没有银河系中心位置中微子浓度以及宇宙空间星系的平均距离之类的信息情况下，这样的估值也还是有一定的价值的。

考虑到实验装置是在地球上进行测量。而地球上单位体积的中微子数量是宇宙平均数量的 10^{10} 倍，这样如果我们在实验装置中将中微子与光子的相互作用距离设置为 1 米，则可以简单估算出，在实验装置中测量到的光子频率变化大约为 $0.18\mathrm{s}^{-1}/\mathrm{m}$，或者光子波长的变化大约为$7 \times 10^{-14} nm/\mathrm{m}$

从这样的估算结果来看，要测量到这么细微的波长变化，现有的装置可能比较困难。不过对于频率的变化，通过非常灵敏的设备应该还是可以进行测量的。本文给出两种装置来探测这种波长或者频率的变化。分别是利用光线的干涉来测量波长的变化。利用穆斯堡尔效应来测量频率的变化。

4 利用光线的干涉效应探测光子与中微子的相互作用

对于光线频率细小变化的测量可以通过光线的干涉条纹来进行。这里给出图 1 所示的测量装置。

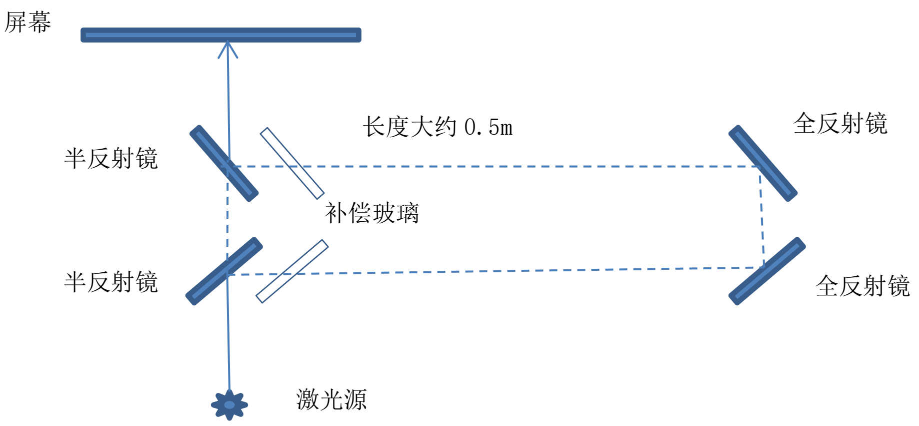

图 1 利用光线干涉效应测量光子中微子相互作用

在图 1 的装置中激光源发出的光线经过半反射镜之后分成两路，一路继续直线运行，照射到屏幕。另一路则 90 度折射之后通过右边的两个全反射镜又反射回来。并通过第二面半反射镜反射到屏幕上。由于两束光线的光程差不同，就会在屏幕上形成干涉图案。而一旦其中一束光线受到中微子的影响而导致频率发生微弱的变化，就可以通过屏幕上的干涉条纹变化显示出来。

图 1 显示的装置与迈克尔逊干涉仪的原理基本相同。按照目前迈克尔逊干涉仪能够测量到的波长变化的精度大约在 10^{-2}nm 来考虑，用该装置测量太阳中微子与光子的相互作用可能精度不够。不过如果中微子的浓度能够提高 10^{10} 倍，则该装置应该能够测量到比较明显的波长变化效应。比如在反应堆旁边，中微子的浓度应该可以接近这样的数量级。

5 利用穆斯堡尔效应探测光子与中微子的相互作用

利用光线干涉效应一般适用于可见光，而可见光的频率比较低，导致整个实验结果的精度不够。穆斯堡尔效应使用了伽马射线，能量非常高，故能够以很高的精度来测量光子频率的变化。诸如 ^{107}Ag 的精度可以达到$\frac{\Delta E}{E}\sim 10^{-22}$，这样就可以满足$\frac{\Delta f}{f}=10^{-16}$频率变化的测量需求。

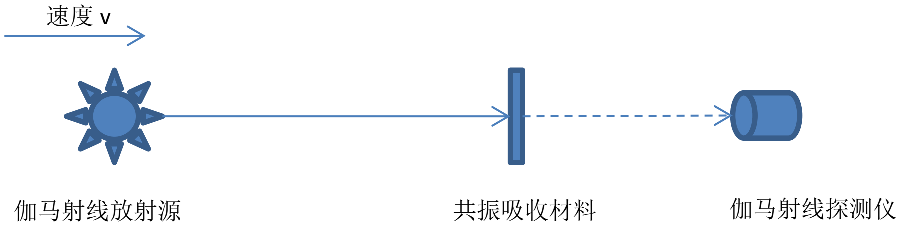

图 2 利用穆斯堡尔效应探测光子中微子相互作用

图 2 显示装置中，伽马射线放射源与共振吸收材料之间的距离可以按照实验精度的需求来进行调节。距离越长，获得的实验精度越高。

实际上已经有利用穆斯堡尔效应测量引力红移的实验结果。而且实验所测量的光线频率变化的数量级与本实验的实验精度需求差不多。证明穆斯堡尔效应是能够满足获得足够精确结果的需求的。

另外从文献【10】给出的实验数据来看，无论是放射源放在塔顶还是塔底，所测量到的伽马射线都是出现红移，而按照理论预测，从塔顶发射的伽马射线应该在塔底测量到蓝移。说明这其中出现了一个很大的系统误差。文献【10】并没有给出具体的解释。

这里考虑伽马射线可能与中微子产生的相互作用。按照文献【10】中的数据，可以计算出平均红移的频率为：

$$\Delta \mathrm{f} = -17.6 \times \frac{3.6 \times 10^{18}}{10^{15}} = -6.3 \times 10^{4} Hz$$

上面的数据中，负号表示红移。

而本文按照星系红移估算出来的频移数据，对于频率大约为 10^{14}Hz 频率的光线，其每米的频移大约 0.18Hz，而实验装置中的放射源与吸收体之间的距离达到了 22.5 米，再考虑实验中的伽马射线频率高很多，因此其频移也等比例放大。这样可以估算出该实验装置中，中微子对伽马射线频移的影响大约为$4.5 \times 10^{4} Hz$，这与实验值数量级上还是相一致的。或许能说明，在文献【10】中所涉及到的系统误差，至少有一部分是由于光子与中微子相互作用而引起的。如果需要对此进行验证的话，可以考虑将该装置安装在中微子浓度比较高的地方再进行测量，应该能够测量到更大的红移数值。

6 结论

本文探讨了如何利用光子与中微子的相互作用来进行中微子的探测。如果本文结论获得实验验证，将能够提供一种新的方法来探测中微子，也有助于促进中微子探测设备的小型化和探测精度的大幅度提高。

从已有的理论分析以及实验数据来看，中微子与光子的相互作用还是有很多理论和实验支持的。只是中微子与光子相互作用的散射截面方面还存在很多的不确定性。即这个截面会不会太小，而最终没有什么利用价值？本文利用宇宙星系红移以及利用穆斯堡尔效应验证引力红移的实验数据进行分析，认为中微子与光子相互作用的反应截面可能会比较大，足以利用穆斯堡尔效应来进行探测。

不过本文的分析还是存在一些不足的。主要表现在以下几个方面：

1、由于缺乏更精确的数据，宇宙星系红移数据估算的误差比较大，因此所得出的结论可能需要更多的实验进行验证和修正。

2、利用已有的穆斯堡尔效应探测引力红移的数据进行分析，尽管能够得到与预测比较一致的结果，但限于所获得的数据较少，很难排除其他因素对于伽马射线红移的影响。比如伽马射线的康普顿散射也可能导致

红移现象。因此可能需要进一步的实验来进行分辨，究竟这些红移现象是康普顿散射引起还是中微子与光子相互作用引起的。

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