Philosophy Study, April 2022, Vol. 12, No. 4, 181-184
doi: 10.17265/2159-5313/2022.04.001

# Some Progresses in Astronomy, and Three Predictions of Gravitational Wave

Yi-Fang Chang
Yunnan University, Kunming, China

The big progresses in astronomy and universe are all related to important philosophy of science. Based on general relativity, we discuss some progresses: binary stars and their form, negative matter, and inflation, etc. Then we propose three predictions of gravitational waves: their observations must be nonlinear waves; velocity of gravitational wave should be slightly higher than the velocity of light; gravitational waves in black holes may emit and be observed. The directed gravitational wave observatories for high-energy astrophysics are proposed.

*Keywords:* philosophy of science, general relativity, gravitational wave, binary stars, black hole, negative matter

## Introduction

In 1788 Great philosopher I. Kant in *The Critique of Practical Reason* said, “Two things fill the mind with ever new and increasing admiration and awe, the oftener and more steadily we reflect on them: the starry above and moral law within”. For modern science great astronomer Eddington (1939) studied the epistemology of relativity and quantum theory.

Human knowledge for astronomy and universe is a deepening process from Copernicus, Newton to Einstein, from big bang, inflation to dark matter, dark energy. Astronomical observations are developed from general optics to full-band electromagnetic waves, cosmic ray, neutrinos, and gravitational waves, etc. These directly involve the human world view. Pulsar, the cosmic microwave background radiation, and its anisotropic (Mather, 2007), etc., are winning more and more of the Nobel Prize in physics due to their advances in astronomy.

## Some Progress in Astronomy

Now the most exact theory in astronomy and cosmology is general relativity. Its base is well-known Einstein gravitational field equations:

$$G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 8\pi k T_{\mu\nu} \tag{1}$$

Actually most stars are in binary systems, perhaps up to 85% of stars in astronomy. It broke the secular thinking on “there have not two Suns in sky, there have not two emperors in people” confined by the solar system. Based on the basic equations of a rotating disk on the nebula, we applied the qualitative analysis theory of nonlinear equation, and obtained the nonlinear dynamical model of formation of binary stars (Zhang, 2000). Steinitz and Farbiash (2003) established the correlation between the spins in binaries, and this result might be

Yi-Fang Chang, Professor, Department of Physics, Yunnan University, Kunming, China.

related to Zhang's nonlinear model for the formation of binary stars from a nebula. Based on the hydrodynamics and hydromagnetics of nebula, we discussed the formation of binary stars by the qualitative analysis theory (Chang, 2007a). Further, based on the Lorenz model derived from the equations of hydrodynamics of nebula, we derived the formation of binary stars, in which the two wings in the Lorenz model form just the binary stars. The base of the most exact evolutionary theory of large scale structures must be general relativity and Equation (1), whose 2+1 dimensional plane equations of gravitational field are calculated. Based on these equations, we obtained the evolutions of disk nebula by the qualitative analysis theory, in which the binary stars or single star are formed for different conditions. This is the most exact model of formation of binary stars (Chang, 2013). The nonlinear interaction plays a crucial role, and is necessary condition of the formation of binary stars and of multiple stars.

Dark matter and dark energy as two basic problems of modern science are very important in philosophy. General hypothesis is that both are two different concepts. But, so far some models on dark matter and dark energy are not testability in epistemology. Based on Dirac's negative energy, from 2007 we proposed the negative matter, which is different from opposite matter. They can form a perfect symmetrical world (Chang, 2007b; 2021). The negative matter may be the simplest model of unified dark matter and dark energy. We calculated an evolutional ratio between total matter and usual matter, and proposed a judgment test of the negative matter as dark matter is an opposite repulsive lensing, and other eight possible tests. This is a testable and calculable model (Chang, 2021).

Cosmos and its origin are always important problem in philosophy. In cosmology Guth first proposed inflation is an important progress, whose time origin is from $10^{-32}$s, and cosmic scale factor exponential expansion $a(t) \approx e^{Ht}$. The universe has expanded at least $10^{26}$ times. Inflation explains the flatness and horizon, etc. Then Linde (1982) and Albrecht et al. (1982) developed the chaotic inflation. But, so far this has not a reasonable mechanism of inflation, and only a scalar field is introduced phenomenally.

We proposed that the mechanism of inflation is origin of positive-negative matters created with a huge repulsive force at the same time in quantum fluctuations. This corresponds to the cosmological mode created from nothing to all things from vacuum (Chang, 2007b; 2021). At very small scale it is similar to the strong repulsion field, and produces quantum effect, and the interaction between positive-negative matters is nonlinear, which may obtain chaos, which may form the Linde chaotic inflation, but both differences are different scales and times. According to this model, inflation should end on a strong interaction scale $R_e = R_i e^N \approx 10^{-13} cm$.

We assume that positive matter and negative matter are respectively the same gravitation fields only with different positive or negative mass (Chang, 2007b; 2021), and correspond to Riemannian geometry and closed universe. The positive and negative matters are repulsion each other, which is probably Lobachevskian geometry and open universe, and derived cosmic accelerated expansion.

## Gravitational Wave and Its Three Predictions

Recently, gravitational wave forms a focus of scientific development. Its basic equation is $R_{\mu\nu} = 0$. First, Abbott et al. (2016a; 2016b) observed gravitational waves GW150914 from a binary black hole (BBH) merger. We forecast that further investigations may discover difference between gravitational wave and electromagnetic wave (Chang, 2016). Abbott et al. (2017) observed gravitational waves from a binary neutron star (BNS) in spiral, and detectors observed association with the γ-ray burst (GRB) 1.7s after GW170817. This proved clearly both velocities of gravitational wave and electromagnetic wave are different (Chang, 1996).

Further, GW190412 is originated from the merger of two black holes with unequal masses respectively about 30 and 8 times the mass of the Sun ($M_\odot$). GW190425 is originated from the merger of a compact binary with total mass of about $3.4M_\odot$. Abbott et al. (2020) observed GW190521, in which a binary black hole merger with a total mass of $150M_\odot$.

We propose three predictions of gravitational waves:

(1) Einstein gravitational field equations (1) are nonlinear, so long as the equations are not the simplest linear equations at first approximation, their solutions cannot be a simple linear wave. It originates from a nonlinear essence of the gravitational field. We obtained quantitatively some simple nonlinear solutions (Chang, 1996). The observed gravitational waves must be the strong gravitational fields, which are generally nonlinear equations.

(2) We proposed that the two propagation velocities are different i.e. the velocity of the gravitational wave should be slightly higher than the velocity of light, because at least since light deflects while the gravitational wave propagates along a straight line in a strong gravitational field, like an electromagnetic wave in an electromagnetic field, in particular when photon-photon interactions are neglected (Chang, 1996).

For GW170817 a new character is to observe association with the γ-ray burst (GRB) 170817A which was observed 1.7s after GW170817. This is very small value, but, it showed clearly that velocities of two waves are different (Chang, 1996), and are inevitable result of general relativity. We calculated simply its gravitational red shift and the deflection of light, whose delay time is 0.1792s (Chang, 2018).

(3) Since light deflects in a strong gravitational field, as such in black holes, but the gravitational wave propagates along a straight line, therefore, the gravitational waves in black holes should be able to emit and be observed. Therefore, black holes only radiate gravitational waves without emitting electromagnetic-light waves.

It is known that the black holes have only three observables: mass M, angle momentum J, and charge Q. Theoretically, three may all produce gravitational waves, such as Kerr black holes.

Various high-energy celestial phenomena, such as supernovae, GRB, active galactic nuclei, huge jets, quasars, etc., and their changes, should produce gravitational waves. If they accompany electromagnetic waves, it will be able to test the difference of velocities between gravitational and electromagnetic waves. We should research some aspects of gravitational waves, such as gravitational wave theory of accretion disks and jets, and stationary or discontinuous mutations inside black holes, etc. Further, we can develop some directed gravitational wave observatories, such as for the huge black holes in the Galactic center.

Our above research is all based on general relativity and equation (1). In the face of the vast universe and many profound mysteries, the human living on the Earth is very small, not to mention the individual. Reasonable people must improve their outlook on life, and dilute fame, and fortune. We should remember what Einstein said: “The search and striving for truth and knowledge is one of the highest of man’s virtues”.

## References

Abbott, B. P., Abbott, R., Abbott, T. D., Acernese, F., Ackley, K., Adams, C., ... Zweizi, J. (2016a). Observation of gravitational waves from a binary black hole merger. *Phys. Rev. Lett., 116*, 061102.

Abbott, B. P., Abbott, R., Abbott, T. D., Acernese, F., Ackley, K., Adams, C., ... Zweizi, J. (2016b). LIGO bags another black hole merger. *Phys. Rev. Lett., 116*, 241103.

Abbott, B. P., Abbott, R., Abbott, T. D., Acernese, F., Ackley, K., Adams, C., ... Zweizi, J. (2017). GW170817: Observation of gravitational waves from a binary neutron star Inspiral. *Phys. Rev. Lett., 119*, 161101.

Abbott, B. P., Abbott, T. D., Abraham, S., Acernese, F., Ackley, K., Adams, C., ... Zweizi, J. (2020). GW190521: A binary black hole merger with a total mass of $150M_\odot$. *Phys. Rev. Lett., 125*, 101102.

Albrecht, A., & Steinhardt, P. J. (1982). Cosmology for grand unified theories with radiatively induced symmetry breaking. *Physical Review Letters, 48*(17), 1220-1223.

Chang, Y. F. (1996). Nonlinear nature of gravitational wave. *Apeiron, 3*(2), 30-32.

Chang, Y. F. (2007a). Hydrodynamics and a nonlinear dynamical formation model on binary stars. *Physica Scripta, 76*(4), 385-387.

Chang, Y. F. (2007b). Negative matter, repulsion force, dark matter and inflation cosmos, Higgs mechanism. Retrieved from https://arxiv.org/vc/arxiv/papers/0705/0705.2908v2.pdf

Chang, Y. F. (2013). Lorenz model and plane general relativity model on formulation of binary stars. *International Journal of Modern Theoretical Physics, 2*(1), 1-12.

Chang, Y. F. (2016). Calabi-Yau manifolds of nebula-galaxies and their possible dynamics, and gravitational wave. *International Journal of Theoretical Physics, 5*(1), 22-38.

Chang, Y. F. (2018). Basic principles of physics and their applications, and logical structure of quantum mechanics. *International Journal of Modern Theoretical Physics, 7*(1), 16-39.

Chang, Y. F. (2021). Development of matter and testable negative matter as unified dark matter and dark energy. *Philosophy Study, 11*(7), 517-526.

Eddington, A. (1939). *The philosophy of physical science.* Cambridge: Cambridge University Press.

Linde, A. D. (1982). A new inflationary universe scenario: A possible solution of the horizon, flatness, homogeneity, isotropy and primordial monopole problems. *Physics Letters B, 108*(6), 389-393.

Mather, J. C. (2007). Nobel lecture: From the Big Bang to the Nobel Prize and beyond. *Rev. Mod. Phys., 79*, 1331-1348.

Steinitz, R., & Farbiash, N. (2003). Spectroscopically and spatially resolving the components of close binary stars. In *Proceedings of ASP Conference Series*, Dubrovnik, Croatia, Oct. 20-24.

Zhang, Y. F. (2000). A nonlinear dynamical model of formation of binary stars from a nebula. *Chinese Astronomy and Astrophysics, 24*(3), 269-274.