Overview of the history of human cognition to the universe

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Abstract:Since the birth of the first telescope in 1608, the scope of the universe which human can observe has no longer been limited by sight. A few years later, the telescope was introduced into the field of astronomical observation by Galileo, Kepler and others, which led to a qualitative change in the development of astronomy. Over the next few hundred years, a wide variety of telescopes with different functions were created and used. In 1990, as the Hubble Telescope was put into use, mankind entered a new era : Observing the universe with astronomical telescopes. Nowadays, telescopes have moved beyond the limits of visible wavelengths to look at all wavelengths. Based on the development history of telescope, this literature review summarizes the research of human beings using telescope to explore and understand the universe. The main conclusion of this review is that the development of astronomy was done by different countries. Each country has made its own contribution at different stages of history. The Hubble Telescope is the epitome of multi-country exchanges and cooperation, This kind of Cooperation in the field of astronomical observation can be extended to different fields such as politics, culture, economy and sports, so as to better promote the progress of human civilization.

Keywords: Universe, Astronomical telescope, Celestial bodies

1.Introduction

Human's understanding of the universe is first obtained from observing various celestial bodies. The messages human receive when attending them come from electromagnetic radiation emitted by those bodies.

To be more specific, electromagnetic radiations from distant celestial bodies must pass through the Earth's atmosphere to reach the ground. In contrast, the atmosphere will cause strong absorption upon many bands of waves during this process. Those waves that the atmosphere did not absorb are in the visible wavelength range from 30mm to 1mm, which forms the atmospheric window, and the wavelengths of infrared light from 22μm to 1μm comprises the infrared window.

For a long time in the past, human observed the universe with their naked eyes in the visible light window. However, with the development of electronic telescopes, human began to make astronomical observations in the infrared window.

2. Development of human cognition of the universe

2.1 Optical telescopes

It is generally believed that the telescope was invented by the Dutch spectacle merchant Liebherr, the person who, in 1608, lined up a convex lens and a concave mirror to check the quality of the ground lens and discovered by chance that the spire of the church seemed to have become closer by using the two lenses to see clearly, which inspired the creation of the first telescope in human history. In the same year, he applied for a patent for his discovery and manufactured a binocular in compliance with the requirements of the relevant authorities(Cheng, 2009).

With the news of the invention of the optical telescope soon spread in European countries, Italian astronomer Galileo quickly made a telescope according to the principle, the objective lens is convex, aperture 4.4cm, focal length 1.2m, the eyepiece is a concave lens, magnification 33 times. Galileo used the telescope to observe the Moon, the Sun and other stars, discovered the position of Jupiter and its moons He also measured the period of sunspots in the same way(Gaiseanu, 2019). These crucial discoveries brought astronomy into the era of the telescope.

In 1611, Kepler, a German astronomer, built on the invention of his predecessor by using two biconvex lenses as an objective and eyepiece. This significantly increased the magnification of the telescope, and this optical system has since been called the Keplerian telescope.

At the present stage, people still use astronomical telescopes with the Keplerian type. It is essential to clarify that the telescopes used a single lens as the objective lens because of the limited technology and severe chromatic aberration. The telescope needed a lens with a minimal curvature to get a better observation effect, however, this would lead to a longer telescope body. Based on the difficulties, the redevelopment of the optical telescope also encountered a bottleneck.

In the mid-18th century, Duron studied the refraction and dispersion of glass and water, established the theoretical basis of achromatic lenses. He made achromatic lenses with coronet glass and flint glass, which solved the previous problem of severe lens chromatic aberration. Thus the long-bodied telescope was replaced by the achromatic refracting telescope. New difficulties accompanied the breakthrough. Due to technical limitations, it was challenging to cast more oversized flint glass(Grunert, 2022). As a result, telescopes widely used the lens length of 10 cm in the early days of achromatic lenses. At the end of the nineteenth century, with the improvement of manufacturing technology, there was a climax in the creation of large-diameter refracting telescopes, especially between 1885 and 1897, seven refracting telescopes of 70 cm or more were created, the most representative of which was the Yerkes telescope with an aperture of one meter and two centimeters created in 1897, whose advantages were long focal length, insensitivity to bending of the lens barrel, et cetera.

For the rest of time, optical telescopes have been moving toward larger sizes. In the 21st century, the new large-field telescope “LAMOST”, which China invented, is located at the National Astronomical Observatory Xinglong Observatory in Xinglong County, Hebei Province. In terms of technology, LAMOST adopts thin mirror active optics and spliced mirror active optics technology on the reflecting Schmidt correction mirror, which breaks the bottleneck of the world’s optical telescopes with large fields of view and large apertures. This technique makes China’s optical technology occupy an important position in the world.

2.2 Spectrum

Newton made rainbows by shining light through a prism, while Wollaston discovered dark lines when he broke down sunlight. J. Fraunhofer discovered that visible rainbows and incompatible dark lines were continuous. He named the arrangement of these rays Fraunhofer lines. He also proved that the Solar’s chemical component is the same as Earth, thus demonstrating that those tellurian chemicals can be found anywhere in the universe. This breakthrough was made by German physicist G. Kirchhoff, which laid the foundation of astrophysics.

The Harvard Observatory has been cataloging the spectra of stars for four decades, starting in 1886. They based their classification upon the law of identical spectral lines occurring on same-color stars and by ranking it in the order of decreasing temperature: O—B—A—F—G—K—M, G—R—N, K—S. The main sequence ranges from O to M, and the O-type stars have the highest effective temperature while the M-type stars are the most freezing. Every type of star is additionally sorted into ten quadratic forms. For example, the hottest star of B-type is B0, and the coolest is B9. It is worth noting that there are embranchments in star types G and K, respectively R and N, and S. R-type and N-type stars contain carbon majorly, while S-type stars contain mostly cryogenic heavy metal.

In 1905, Denmark astronomer E. Hertzsprung discovered that there are some stars with very low luminosity and some stars with very high luminosity in K-type and M-type. He called the former “dwarf star” and “giant star”. In 1911, Hertzsprung determined the luminosity and color of several galactic clusters. Establishing a plane cartesian coordinate system concerning these two quantities marked the points representing stars. He found that most stars appeared on a continuing belt while others appeared in small groups. American astronomer H. Russell sketched a diagram while studying spectra and luminosity in 1913. By comparing those two graphs, people found out that color is equivalent to spectral pattern or surface temperature. This figure type was then called by a joint name—Hertzsprung-Russell Diagram, which has an x-axis for the spectral type or temperature or chromatic index a y-axis for luminosity or absolute magnitude. There are three main stellar religions shown in the diagram, representing three main kinds of stars. The main sequence is the belt through the left side to the right, which contains main sequence stars—stars that take up 90% of our observation, which is the most stable phase of a star’s life. There are red superstars on the top right corner, the massive stars in a milky way, formed after a star departs the main sequence. Down at the left corner, where stars finally evaluate to the last stage—the white dwarfs, it is only 40 million times the size of our Sun. The HR diagram allows scientists to speculate about stars’ evolution and classify discoveries(Velmans, 2021).

2.3 Radio telescope

In 1932, Karl Guthe Jansky in Bell Telephone Laboratories discovered the first radio radiation from the galactic centre. During World WarII, radio workers detected solar radio accidentally. These radar technologies were applied to astronomical observations after WWII kick-started the development of radio astronomy.

In 1942, during World WarII, a British radar operator detected an intense low-frequency solar burst. However, the information was kept secret because it was potentially valuable in evading enemy radar until the war finished. In 1944, the radio emission from the Sun was first discovered by Grote Reber. One of the most important discoveries of the solar radio emission is that the radiation that the Sun produces is way higher than that of the standard black body radiation, as expected. In 1946 Vitaly Ginzburg proposed an explanation for this which indicates that thermal bremsstrahlung emission from a million-degree corona was responsible, and the later radio data have proved the idea.

After James Chadwick discovered the neutron in 1932, Lev Landau indicated that protons and electrons might combine and form neutrons in high temperature and pressure. So it seems possible that there exists a star made entirely of neutrons, which is named neutron star. In 1934, two European Astrophysicists, Walter Baade and Fritz Zwicky proposed that neutron stars can result from supernova explosions. In 1939, American physicists J. Robert Oppenheimer and George Volkoff established the first quantitative neutron star model.

In1967, British astronomer Anthony Hewish and his graduate student Jocelyn Bell Burnell discovered radio pulsar. At that time, the two astronomers built up a substantial long wave receiving antenna array to search for cosmic radio flickers. Since July, 1967, the apparatus has worked on waves with a 3.7-meter wavelength and 81.5 MHz frequency, and Bell is mainly responsible for data processing. After a month of data collecting, Bell spotted a specific signal fluctuation in 30 meters of paper tape every day. It is like some regular pulse without flickers. On November 28, Bell finally determined the existence of a pulse signal with a period of 1.337s. After a series of experiments, Bell and Hewish concluded that this signal came from a place beyond the solar system, with no more significant source than Earth. After ruling out the possibility of an alien signal, Hewish and Bell verified that the signal came from pulsars(PSR)—a theoretical neutron star. (Nather et al., 1990).

From 1948 to 1960, a few hundred radio galaxies were discovered; those galaxies are millions of times more potent than normal optical galaxies. Different from the results of optical observations, which consider galaxies as a relatively stable star system, observations from all length shows that activity is expected in galaxies but varies in size. Those galaxies with a remote activation are defined as normal galaxies, and 2% of galaxies with a tempestuousness activation are defined as active galaxies.

On May 20, 1964, American radio astronomers Robert Wilson and Arno Penzias confirmed the existence of cosmic microwave background radiation(CMB), which provided a piece of solid evidence to support the Big Bang Theory. They made this discovery by accident when doing the absolute measurement of celestial radiation in Bell Lab's Holmdel Horn Antenna. To decrease the noise level of the antenna, they did a series of examinations. Robert and Arno estimated that the radiation when they pointed to the antenna should only be 0.3K. However, then they found out that the result was that there was striking 6.7K radiation, and the radiation was independent of the direction.

Another problem of the galaxies is how the arms formed. Physical models tell that if the arm contains fixed stars and gases, the arm will tighten as the galaxy is spinning. On the contrary, observations tell that in all the spiral galaxies, the shape and size of the arm do not change with time. The explanations for this were proposed in 1963 according to Chinese-American scientists Jiaqiao Lin and Xiasheng Xu. The theory holds that the perturbation of gravitational potential due to the overall rotational velocity and spatial density distribution results in the formation of density waves; the dense crest forms the cantilever. Although the image shows the arms are static, the stars and gases are going in and out of it at any time.

In the 1930s, three types of interstellar molecules, CH and CN have, were identified. Since people thought they were scarce and would be ionized quickly by ultraviolet radiation from the stellar, those molecules have no astrophysical significance. However, after discovering the radio 21cm line, people began to find interstellar molecule OH. Hydrogen is the most abundant element in the universe, and the abundance of oxygen is not low.

2.4 Space telescopes

Because of the atmosphere, we can only use radio, visible lights, and infrared windows to observe the ground, which greatly people's exploration of the universe. Even at visible light bands, the observations are interrupted by the transparency of the atmosphere and city lights. While upon the atmosphere, at altitudes of more than 100 kilometres, it is entirely free of the influence of the atmosphere, which is possible to carry through long-time, full-wave band observations.

The Hubble Space Telescope(HST) is the most well-known space telescope in visible light bands. It was sent to space on April 25, 1990 by space shuttle "Discovery" and remained in operation. The telescope's primary mirror has a diameter of 2.4 meters, a length of 13.6 meters, and a ground weight of 12.5 tons. It mainly works in visible light bands, and it can also be partly used in parts of observations in ultraviolet and infrared light range.

Another famous telescope is the Kepler Space Telescope, the first space detector used to search for Earth-like planets outside our solar system. The telescope was sent to space on March 7, 2009, and it has empathetic detection capabilities. Since the telescope came into operation, it has discovered five extrasolar planets. Until today, more than 1200 extrasolar planets have been found by Kepler Space Telescope, with 54 planets in the "habitable zone"(Tyson,2002)

The main target of microwave observation is cosmic microwave background radiation. On November 18, 1989, satellite COBE(Cosmic Background Explorer) was launched by NASA. Researchers obtained results from the satellite in a short period of time. Those results confirmed that the early universe was a hot universe, supporting the Big Bang theory. Later, on June 30, 2001, satellite WMAP(Wilkinson Microwave Anisotropy Probe) was sent to space to do more accurate explorations of the cosmic microwave background radiation. On June 14, 2009, the European satellite PLANK was launched, with a sensitivity ten times more than COBE. Its results are used for the discovery of the origin of the cosmic.

To explore the atmosphere where ultraviolet cannot go through, people use different kinds of space observation equipment. Far Ultraviolet Spectroscopic Explorer satellite(FUSE) was launched in 1998. It was used to study the abundance of elements in the universe, the interstellar medium, and stellar atmospheres to find out the chemical evolution process of the universe.

The two fields of study in X-ray bands and γ- ray bands are the youngest in astronomy. Satellite Uhuru is the first satellite used to make X-ray observations, and it found 339 strong X-ray emitting objects in the first all-sky survey. After Uhuru, NASA's HEAO project used grazing imaging technology to obtain the first X-ray image of a celestial body. After 1990 satellite ROSAT was launched, 150,000 X-ray sources were discovered. AXAF and XMM-Newton's data of X-ray spectrum and X-ray objects are used on studies about late stellar evolution, the detection of black holes, and dark matter(Leane et al,2021)

The first γ-ray satellite, Explorer XI weighed only 30 pounds. After that, the satellites and instruments sent to space become more sensitive and heavier. Those apparatus detected thousands of cosmic gamma-ray bursts and provided essential data for high-energy astrophysics research.

3. Conclusions

1. The promotion of astronomy for the progress of human civilization and the development of natural science is mainly reflected in two aspects: Firstly, astronomical observation provides basis for the establishment of major scientific theories and tests their correctness; Secondly, in the process of understanding the earth, life and its place in the universe, the new astronomical observations have gradually and continuously changed the whole human view of the universe. The search for extrasolar planets and life will be driven by our innate curiosity and thirst for knowledge.

2. The study of the motions of celestial bodies in the solar system directly led to the establishment of Newtonian mechanics system, which forms the theoretical foundation of the first scientific and technological revolution. More recently, both dark matter and dark energy have been discovered in astronomical observations. The study of black holes is the core problem of quantum gravity theory. Once these problems are solved in the future, the basic theory of natural science will be greatly promoted. The progress of basic theory is a necessary condition for the advancement of human science and technology.

3.The development of the Hubble telescope included many European countries, and several major European countries in the development of modern civilization have shown through the Hubble telescope development to have closer technological and cultural exchanges. It also contributed to the outstanding achievements made in other fields of science later on. The Hubble telescope is only a microcosm of this exchange and cooperation that has expanded into different fields such as politics, culture, economy and humanities.

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