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| RESEARCH ARTICLE

Innovative Application of the Artistic Modeling of Ancient Chinese Astronomical Instruments in Modern Design: A Case Study of the Armillary Sphere

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| ABSTRACT

Ancient Chinese astronomical instruments, exemplifying classical Chinese traditional artefact design, represent a perfect amalgamation of ancient China's advanced scientific and technological prowess with the aesthetic philosophy underlying traditional Chinese artefact creation. Their scientific and artistic values are considerable and should not be underestimated. This research introduces these instruments' concepts, design characteristics, and innovative application cases, mainly focusing on the armillary sphere from an artistic design perspective. This research employs a mixed-methods approach, including surveys, literature reviews, and systematic analysis; the research examines the instruments' design features and cultural significance. The objective of the study is to highlight the armillary sphere's potential as a source of inspiration across various modern design domains, such as sculpture and installation, fashion accessory design and stage performance. The study concludes that reinterpreting these ancient astronomical instruments in modern design not only preserves cultural heritage but also encourages cross-border innovation. This fusion approach offers new perspectives for designers, blending traditional Chinese culture with contemporary design practice. Future research is suggested to explore the integration and wider application of ancient Chinese astronomical instruments in modern design.

| KEYWORDS

Ancient Chinese astronomical instruments; Armillary sphere; Modern design applications; History and innovation; Cultural heritage preservation

| ARTICLE INFORMATION

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1. Introduction

The rich history and profound cultural heritage of ancient Chinese civilization have nurtured a range of unique and exquisite astronomical instruments. From early sundials to sophisticated armillary spheres, these ancient instruments are crystallizations of scientific technology and physical representations of ancient wisdom and philosophical thought. They embody ancient understandings of celestial movements, reflecting a deep comprehension of the universe and time within ancient Chinese culture. Guided by the philosophy of "unity of heaven and humanity," these instruments were used for observation and timekeeping, symbolizing the harmonious coexistence of humans and nature.

With the development of modern design studies, it has become particularly important to explore the application of these ancient instruments in modern design. This paper first reviews the history and stylistic features of ancient Chinese astronomical instruments as well as the armillary sphere, and then demonstrates through case studies how these stylistic features and design elements have been reinterpreted and reapplied in modern design, and how this process has contributed to the fusion of traditional culture and modern design. Through this cross-generational dialog, we will promote preserving and disseminating traditional crafts in modern society and inspire new thinking and innovative possibilities in contemporary design.

2. Overview of Ancient Chinese Astronomical Instrument Design

The achievements of ancient Chinese astronomy can be roughly divided into three aspects: "celestial observation," "compilation and legislation," and "instrument production." Astronomical instruments are divided into five types according to different purposes: observation, timing, demonstration, astrology, and calculation (Su, 2010). Some of these astronomical instruments have only one function, some have two or three functions simultaneously, and their superposition and combination constitute a variety of known astronomical instruments (Zhang, 2018). In his History of Ancient Chinese Astronomical Instruments, Pan Nai counted "four peaks of astronomical instrument construction in Chinese history, namely, the Northern and Southern Dynasties, the Tang, the Northern Song, and the Yuan" (Pan, 2005). The diversity and complexity of ancient Chinese astronomical instruments are some of their unique aspects. The most well-known instruments include the armillary sphere, sundial, and water clock. These demonstrate the achievements of ancient Chinese astronomy and horology in technology and reflect the wisdom of ancient craftsmen in art and craft. However, instruments like the armillary sphere, sundial, and star disk are scientific devices and symbolic representations, carrying philosophical, religious, and political meanings (Zhang, 2018). Jiang Xiaoyuan explains this in "Astronomy, Wu Xian, and Ling Tai - Astrological Divination and Ancient Chinese Political Opinions." "Ancient Chinese astronomy was essentially a study of communicating with the heavens and gods, serving to connect heaven and humanity. It was a source and symbol of royal authority, with celestial observation, star divination, Ling Tai, and calendrical systems being the most important means of heavenly communication in ancient times." As cultural carriers of astronomy, astronomical instruments have always maintained their cultural significance in calendar verification and political symbolism under the political ideology of "ruling through celestial communication.

3. Methodology

This research mainly adopts three research methods: survey method, literature method and systematic analysis method. Firstly, through the survey method, this study conducts field visits to the existing ancient Chinese astronomical instruments in museums, especially the armillary sphere, to collect relevant pictures, dimensional data, and construction details. In addition, all the literature or books related to ancient Chinese astronomical instruments are collected, and the contents that may be relevant to the study are extracted and organized. The relevant data and conclusions obtained from reading the literature are referenced and cited to provide a scientific basis and theoretical support for discussing astronomical instruments in this paper. However, the focus of the literature is still concentrated on the ancient astronomical instruments in the field of creation ideas, casting technology, and other areas related to artistic modeling. Finally, the systematic analysis method is adopted to comprehensively analyze the armillary sphere's stylistic structure and design concept and to explore its modern design applications on different occasions, aiming to reveal the inspiration of its artistic styling to modern design. This multi-faceted research method helps to deeply understand the innovative application of ancient astronomical instruments in modern design. It provides new perspectives and inspirations for the field of modern design.

4. Modeling Features of Ancient Chinese Astronomical Instruments: The Case of the Armillary Sphere

The design principles of ancient Chinese astronomical instruments encompass a fusion of astronomy, mathematics, physics, and the fine arts. These instruments' design and creation are not just simulations and measurements of physical phenomena; they also embody the ancients' understanding and respect for the universe and natural laws.

The "Modern Chinese Dictionary" defines the armillary sphere as "Hun Yi" and "Hun Xiang." Hun Xiang, akin to modern celestial globes, is a demonstrative astronomical instrument. Hun Yi, also known as the armillary sphere, is an astronomical measuring instrument. In ancient China, the armillary sphere often collectively referred to both Hun Yi and the celestial globe that demonstrates the diurnal rotation of the heavens, known as Hun Xiang (also called Hun Tian Yi) (Jiang, 1991).

4.1 A Structure Form That Embodies the Universe

From the perspective of their conceptual origins, ancient Chinese astronomical instruments like the armillary sphere possess a structure that embodies the universe. "Zhou Yi Jing Jie" states, "The great man aligns his virtue with heaven and earth, his brilliance with the sun and moon, and his order with the four seasons" (Wang, 2011; Yang, 2015). Taoism believes that everything, including humans, originates from nature, and human activities must conform to natural laws. Zhuangzi first proposed the concept of "unity of heaven and man" in "Qi Wu Lun," stating, "Heaven and earth were born at the same time as I and the ten thousand things are one with me." Ancient Chinese astronomical instruments serve as a medium of communication between our ancestors and nature, with their designs reflecting the philosophical ideas of "embracing the universe" and "unity of heaven and man," thus exuding a grand and expansive aura.

Regarding structural morphology, the traditional Chinese concept of "the vessel carries the Tao" is embodied in the design of ancient Chinese astronomical instruments. These designs convey the realm and interest of "Tao" through their form, providing aesthetic pleasure. Li (1988) said, "Analogies, metaphors, and symbols in traditional Chinese thinking are essentially the same form. Metaphor is an expression of analogy, and symbolism is a form of metaphor". These three share the commonality of using existing

natural phenomena or principles to express specific emotions or meanings. For instance, the design of the armillary sphere not only accurately simulates celestial movements but also reflects the philosophical idea of the ancient Chinese cosmological view of "round heaven and square earth. (Li, 2016)" Zhang Heng's "Commentary on the Armillary Sphere" describes, "The celestial sphere is like a chicken egg; the heaven is round like a bullet, and the earth is like the yolk inside the egg" (Chen, 1984). The hollow copper sphere representing "round heaven" or the universe has the ecliptic and celestial equator on its surface, along with grids indicating specific celestial positions (Figure 1). In these instruments, we observe ancient Chinese attempts to seek harmony between humans, nature, and the cosmos through observing and simulating astronomical phenomena.

Figure 1: Hu Xiang (left), Celestial Globes (center) and their common structure (right)

4.2 Rustic and Elegant Color Texture

From an aesthetic value standpoint, another feature of ancient astronomical instrument design is the combination of practicality and artistic beauty, reflecting the ancient Chinese philosophy of "utility" in craftsmanship. Most ancient Chinese astronomical instruments prioritized practicality to meet people's needs. Scientists like Zhang Heng, who represented this philosophy, opposed excessive decoration and advocated for a utility-centered approach to craftsmanship, skillfully integrating aesthetics (Zhu, 2009). The color texture of ancient Chinese astronomical instruments relates to their casting materials and techniques, resulting in their rustic and elegant color texture. For example, the armillary sphere and Jian Yi from the Ming Dynasty on the Zijinshan Observatory in Nanjing, made of bronze with a dark green hue, exude a rustic and mysterious beauty with rich and varied decorations. The gold-inlaid pearl celestial globe from the Qianlong period of the Qing Dynasty, made of gold for the ecliptic and equator and embedded with pearls of various sizes, presents a grand and noble aesthetic (Figure 2).

Figure 2: Gold and Pearl Celestial Globe

4.3 Nature-Inspired Pattern Decoration

Many ancient astronomical instruments feature beast, dragon, phoenix, and flame patterns derived from nature, indicating the ancients' penchant for integrating natural imagery into their designs. However, "following nature" does not equate to "imitating nature" but emphasizes the subjectivity and creativity in the creation process. With its diverse elements like squares, circles, long, short, sharp, and flat shapes, nature molds everything in the world into myriad forms. The patterns on astronomical instruments stem from the ancients' observations and imaginations of nature. The worship of natural objects by ancestors in different periods, such as turtles, birds, frogs, fish, the sun, and the moon, reflects both totemic reverence and royal authority.

Figure 3: Dragon pattern (first from left), cloud pattern (second from middle) and turtle (first from right)

The most common totemic worships are the cast dragons on the armillary sphere and the cloud-dragon patterns. The cloud-dragon pattern comprises clouds and dragons, with the dragon as the main element and the dragon roaming among the clouds (Figure 3). These patterns typically appear on the stands of astronomical instruments that wrap around the structure of the base. Although dragons are not real-life species, they symbolize the Chinese nation and are quintessential representatives of traditional culture. As a divine beast that passes through the heavens, the dragon is a symbol of auspiciousness, and in ancient times, only imperial robes could be embroidered with dragon patterns. This further substantiates the connection between astronomical instruments and imperial authority. Corresponding to the dragon and the cloud pattern are the turtle and the water pattern, usually found on the base of astronomical instruments. The turtle, derived from the 'Black Tortoise' among the four mythological creatures, represents 'Earth' due to its aquatic habitat.

The design and construction of ancient Chinese astronomical instruments symbolize antiquity's technological achievements and constitute a significant part of cultural heritage and artistic creation. These instruments played a crucial role in ancient society and continue to possess immeasurable cultural and educational value in today's world. By delving into and studying the design principles and philosophical thoughts behind these astronomical instruments, we can better comprehend the splendid achievements of ancient Chinese culture, science, and technology while providing a rich source of inspiration and resources for modern design.

5. Integration of Tradition and Modernity: Innovative Design Practices

The application of the design principles and aesthetics of ancient Chinese astronomical instruments in the modern design field represents a form of cross-era innovation. These ancient instruments were revolutionary not only in terms of technology but also had profound impacts on art and culture. In modern design practices, elements from these ancient instruments are reinterpreted and applied to create historically resonant works in line with contemporary aesthetics.

5.1 Sculpture and Installation Art

For instance, in public art installations and sculptures, the artistic form and design principles of ancient astronomical instruments, such as the armillary sphere, have been used as sources of inspiration. Some individual artists have created exquisite sculptures based on ancient Chinese astronomical instruments (Figure 4). Some of these sculptures are displayed in public spaces, like the main sculpture, "Between Heaven and Earth," at Hefei Peace Plaza. In his initial design and creation, Sculptor Huang Zhen integrated the spherical features of the ancient Hun Yi with modern artistic forms, creating a spherical structure composed of intersecting circular rings, conveying a strong sense of cohesion and a vibrant upward motion. The "Ends of the Earth Star" sculpture in Hainan is a reimagining of the equatorial sextant (a variant of the armillary sphere), with three rings, each partially intersected but cohesively nested to form a spherical shape, characterized by simplicity and modern style (Figure 5). This sculpture also integrates relevant astronomical elements into its setting, with a ring of twenty-four toad statues around the pool representing the twenty-four hours and the twenty-four solar terms of the Chinese lunar calendar, all derived from simplifying and redesigning scales or elements from ancient astronomical instruments. These designs are not mere imitations of ancient instruments but modern reinterpretations and innovations of their design principles and cultural connotations.

Figure 4: Kanako Nagai's "Armillary Sphere" (left); "Between Heaven and Earth" sculpture in Peace Square (second from left) Fig.

Figure 5: Ends of the Earth Star

At the Shanghai World Expo, the concept of using a golden key suspended in an "armillary sphere" to open the gates of the Expo Park was a re-creation focusing on the circular structure of the Hun Yi (as shown in Figure 6). The prototype for this installation was the equatorial sextant, a variant of the armillary sphere, retaining the three measuring rings (meridian, equatorial, and ecliptic) of the sextant but rearranging their angles and replacing the central "polar axis" with a key shape, creating a structure with smooth, rhythmic lines, layered like the armillary sphere. This innovated "armillary sphere," incorporating modern technology, successfully innovated both the form and function of the armillary sphere, reflecting what the general director of the opening ceremony, Li Xi Zhi, said: "The inheritance of civilization and technological innovation are the two 'golden keys' to humanity's bright future" (Liu, 2010). Contemporary designers need to ponder collectively how to transform the profound and ancient traditional culture into products that the public can experience, understand, and consume.

Figure 6: Opening Ceremony of Shanghai World Expo

5.2 Fashion and Jewelry Design

In fashion and jewelry design, the structural characteristics of the armillary sphere have been utilized to create unique design pieces. A 16th-century German astronomical sphere ring, now a popular internet sensation, serves as a modern example (Figure 7). The armillary sphere ring retains the circular, layered structure of the Hun Yi, with zodiac totems, eight planetary totems, and ancient navigational instrument imagery intricately engraved on each ring. This design is both ingenious and innovative, carrying the scientific structure of the armillary sphere and a romantic symbolism: "Closed, it symbolizes love; opened, it represents the universe" (Little fox, 2019). Similar accessories include armillary sphere necklaces and earrings. These pieces are visually captivating and incorporate the complex structure and exquisite details of ancient astronomical instruments, becoming exemplars of the fusion of modern fashion and classical aesthetics.

Figure 7: Armillary Sphere Ring and Earrings

Beyond spatial three-dimensional design inspirations, the color patterns of the armillary sphere also hold significant artistic value. With its complex and beautiful circular lines, the armillary sphere is frequently used as a retro element or pattern in cultural and

creative products. For instance, stamps and bookmarks inspired by the armillary sphere specifically magnify elements representing heavenly stems, earthly branches, months, and hours from the real Hun Yi, incorporating design symbols like birds and musical notes (Figure 8). These ancient characters, scales, and various dot-line-surface elements inherently possess strong decorative qualities (Figure 9).

Figure 8: Armillary Sphere Stamp

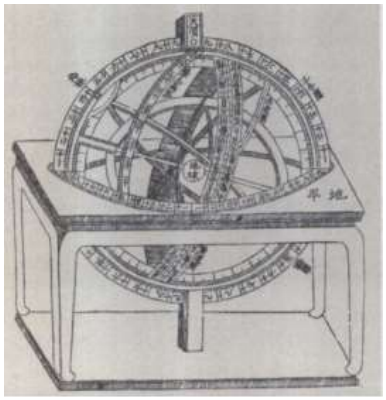

Figure 9: Illustration of Armillary Sphere from Ming Dynasty's Johann Schreck's "Explanation of the Armillary Sphere" (right)

5.3 Stage and Performance Art

In stage performances, the visual design and elements of the armillary sphere have been cleverly adapted and applied. For example, one of the highlights of "The Voice of the Silk Road" is its rendition of the armillary sphere. This version modifies the obliquity of the ecliptic from Li Chunfeng's original Hun Yi, adding an arrow through the axis and replacing the innermost "Si You Yi" structure with a platform for performers (Figure 10). As a spherical stage prop accompanied by lighting and sound effects, the armillary sphere uniquely assists the protagonist in accomplishing a time-travel task. The armillary sphere is also featured in the poster design for the musical "The Voice of the Silk Road." The Nie Jingzhu design team, known for constructing contemporary theatrical aesthetic symbols, indicates that as a visual element, the armillary sphere inherently carries a profound historical and mysterious quality. Its use as a stage prop plays a significant role in narrative storytelling (Silk Road Joy World, 2021), enhancing the poster's mysterious allure (Figure 11).

Figure 10: Performance of "The Voice of the Silk Road"

Figure 11: Poster for "The Voice of the Silk Road" (right)

In the 2021 Henan TV Spring Festival Gala program "Between Heaven and Earth," the armillary sphere was featured in a Tai Chi performance as a stage effect. This act utilized digital technology to incorporate the armillary sphere's layered, changing circular structure into the dance, blending elements and concepts of Tai Chi, ancient dreams of flight, and modern aerospace endeavors, leaving the audience longing for more (Figure 12). The integration of the armillary sphere with astronauts narrates the Chinese people's millennia-long pursuit of cosmic exploration. This fusion of ancient and contemporary cultural elements displays the grandeur of technological and mechanical civilization and reflects the depth and inclusiveness of Chinese historical culture.

Figure 12: Performance of "Between Heaven and Earth"

Through these examples, we can see that translating the artistic modeling of ancient Chinese astronomical instruments into modern design practice embodies cultural and technological innovation and reconfiguration. In the past, these ancient astronomical instruments were mainly used for astronomical observation and time measurement, and their design focused on precision and functionality. In modern design, these principles and forms are reinterpreted and reapplied, perhaps focusing less on their original functionality and more on their cultural value and aesthetic expression. Designers can integrate the classic elements of these ancient astronomical instruments into product design, architectural design, stage art and other fields to create works with deep cultural connotations and modern aesthetic value. These design works are not only the inheritance of ancient technology but also a modern interpretation and innovation of traditional Chinese culture.

6. Discussion and Future Outlook

6.1 Challenges and Opportunities of Artistic Modeling of Astronomical Instruments in Modern Designs

Incorporating design elements from ancient Chinese astronomical instruments into modern design is an opportunity as well as a challenge. The challenge lies mainly in maintaining the authenticity and completeness of the traditional elements while integrating them innovatively into modern design contexts. This requires designers to have a deep understanding of the culture, craftsmanship, and structural principles of ancient Chinese astronomical instruments, but also the ability to combine traditional elements with modern design concepts. In addition, it is necessary to overcome the difficulties in technical realization to ensure the feasibility and practicality of the design.

However, this integration also brings great opportunities. The use of design elements of ancient Chinese astronomical instruments not only gives modern design a deep cultural connotation but also inspires designers to create new ideas. By transforming classical shapes or patterns into modern expressions, unique and attractive design works can be created, allowing the philosophical ideas and stylistic aesthetics of ancient astronomical instruments to be revitalized in contemporary design and serve as a bridge between the past and the present and between tradition and modernity. This cross-generational design fusion not only reflects respect for and history reference and helps promote cultural diversity and innovation, but also provides new perspectives on cross-border design and demonstrates the infinite possibilities of cross-border design.

6.2 Exploration of Future Research Directions

For the innovative application of the artistic design of ancient Chinese astronomical instruments in modern design, future research can continue to explore several aspects. First, the design principles and cultural significance of a wide range of ancient Chinese astronomical instruments can be studied more extensively and deeply to provide richer inspirations and a theoretical foundation for modern design. Second, research could focus on better integrating modern technologies, such as virtual reality and mixed reality, to innovatively demonstrate and explain the principles of these ancient instruments more vividly and interactively. In addition, research can also explore how to apply the design elements of these ancient astronomical instruments to a broader range of fields, such as environmental art design and educational toy design. Through this interdisciplinary exploration, the design elements of ancient astronomical instruments can be made to play a more significant role in modern society and support the creation of a more colorful and innovative world.

7. Conclusion

This research aims to explore the innovative application of the artistic modelling of ancient Chinese astronomical instruments in modern design, taking the armillary sphere as an example. By analyzing the design concepts, cultural backgrounds, principles, and various applications of ancient Chinese astronomical instruments in modern design, this research demonstrates the effective integration of design elements of ancient astronomical instruments with modern design practices. The study shows that these ancient astronomical instruments are significant in terms of technology and functionality and have profound aesthetic and symbolic implications. Through specific case studies, this research uncovers how the artistic modelling of ancient astronomical instruments can be innovatively applied in modern design, providing a rich source of inspiration for contemporary designers and

contributing significantly to preserving and developing historical and cultural heritage. Applying these artistic models of ancient Chinese astronomical instruments in modern design enables the creation of both aesthetically pleasing and practical works while promoting and disseminating China's rich cultural heritage. However, the study also acknowledges its limitations, such as the need for more in-depth exploration of interdisciplinary collaboration and the potential for further research into adapting more examples of ancient Chinese astronomical instruments for modern design applications.

7.1 Suggestions for Future Design Practices

Based on the findings of this study, this research proposes the following recommendations for future design practice:

(1) Strengthen interdisciplinary research and cross-border design: encourage collaboration among designers, historians, engineers, and artists to jointly explore new ways of applying the artistic modeling and design elements of ancient Chinese astronomical instruments in modern times.
(2) Emphasize the inheritance and innovation of cultural heritage: During the research stage, attention should be paid to the protection and inheritance of ancient cultural heritage, as well as the excavation of cultural background and design concepts, and at the same time, be brave enough to carry out innovations and experiments, to ensure that the design works not only have historical depth but also conform to the modern aesthetics and practical needs.
(3) Technology integration and sustainable design: Combine the artistic modeling of ancient Chinese astronomical instruments with modern technology, such as virtual reality and mixed reality, to demonstrate the principles and aesthetics of the ancient astronomical instruments more vividly to attract a wider audience. Incorporating sustainable concepts into the materials used in the design ensures that the design practice meets contemporary needs and positively impacts the future.
(4) By implementing these recommendations, we can look forward to more possibilities for the modern application of ancient astronomical instrument design while contributing to preserving and transmitting cultural heritage and promoting continuous development and innovation in the design field.

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