PROCEEDINGS OF SCIENCE

Ancient and Modern Technology in Japan

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Abstract

As an example of a technology link from the ancient to the modern, an interesting relation between Japanese Buddhist pagodas and the newly built Tokyo Sky Tree is introduced. Examples of modern imaging technology in radio astronomy are also represented.

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1. Ancient Pagoda and modern technology Link

On May 21, 2012, an annular solar eclipse was observed in Japan. This was one day before the opening of the Tokyo Sky Tree Tower, now the world's highest transmitter tower with a height of 634m. The tower was built mainly for wideband digital TV.
The Tokyo Tower, 333 meters high, was Japan's highest tower before May 22, 2012.
And this year will also be marked by Tasso Tzioumis' 60th birthday.

In Japan there is a considerable number of wooden pagodas in Buddhist temples. It is said that a pagoda is built to keep holy ashes of Buddha. It is also said that by estimating the number of the pagodas ever built someone calculated the total mass of holy ashes to be about one ton! On the very top of the central pillar is a Treasury Ball, Muses (fairies with musical instruments) and Nine Rings attached, with the pillar being independent of the outer building structure, as I will mention again later.. Pagodas are mostly 5 stories, or 3 stories.

Good examples of pagodas can be seen in the ancient city of Nara. Nara was the capital city in the early Japanese history (710-794). The capital then moved to Kyoto for about 1000 years until the Meiji Restoration and Nara changed from a political center, and became a calm religious area, which helped to keep historical and religious buildings.

Horyu-ji temple's pagoda is 31.5m high and was built in 711 AD, and so is now almost 1300 years old, making it the world's oldest wooden building. Eleven times damage to the structure was recorded in the period 1050-1995, but the building survived. It can be said that good maintenance efforts also helped acheive such a long life. And this is also thanks to the ever lasting Buddhism of the people. Yakushi-ji temple has two pagodas (an eastern and a western one), and the eastern one has about the same age and height as Horyu-ji temple's pagoda. Kofuku-ji temple's 51m high pagoda is a re-built one. Todai-ji temple used to be the nation's biggest temple, and the 7-story pagoda there was about 100m high and was built in the 8^{th} century, however the pagoda no longer exists.

Japan has been influenced by many kinds of disasters. Earthquake and tsunami, volcanic explosion/eruption, typhoon and flood, are natural disasters. Fires come from lightning or by human error. The atomic power station problem in Fukushima was triggered by an 9th magnitude earthquake and tsunami plus design problems. The atomic bomb attacks to Hiroshima and Nagasaki were totally criminal acts to the human race. These are not all. You can watch frequent visits of Godzilla to Japan in a series of Godzilla movies (1954 -). In the first movie, Godzilla, dormant for many years deep in the Pacific Ocean, awoke and mutated by a series of hydrogen bomb test explosions by the US. A Japanese fisherman was killed by radiation in 1954 and more fishermen suffered through life. Godzilla is about 50 m tall, very close to the height of pagodas.

Figure 1. Horyu-ji temple's 5^{th} story pagoda and Godzilla.

Japanese buildings have been mostly wooden and were seldom built with bricks or stones, and so fires used to be the biggest problem. It is remarkable to know that no collapses of pagodas are known or recorded in Japan. But how could such tall wooden structures survive strong earthquakes and typhoons? And how can the Tokyo Sky Tree survive in Japan? The measured resonance frequencies of the oldest pagoda in Horyu-ji temple, for example, are 1.11s (1^{st}), 0.4s (2^{nd}) and 0.2s (3^{rd}).

Figure 2. The Tokyo Sky Tree tower (634m), which opened in May 2012.

There is a remarkable similarity in the structure of Japanese Buddhist pagodas and the Tokyo Sky Tree. Pagodas have an almost independent pillar in the center of the structure. The scheme for the pagoda may come from religious or cultural reasons, but the designer of the Tokyo Sky Tree studied how this design may work for the tower by tests and computer simulations, and adopted this approach. The Tokyo Sky Tree adopted a central independent pillar in the center, and the vibration modes of the inner pillar and outer tower were designed to be reasonably in anti-phase to suppress vibration. It is critically important to damp the oscillating frequency of an earthquake. The outer structure and central pillar are loosely connected through an oil damper at the height of 375m.

It is interesting to have such an example in learning for modern very tall transmitting tower from olden pagodas.

The shape of the tower has a specific feature of having “triangular” horizontal shape in the bottom to “circular” in the highest part. This makes interesting different shapes from different viewing direction angles. So the tower shape is neither Dorian or Ionian, but some Entasis feature can be seen. (Figure 3.)

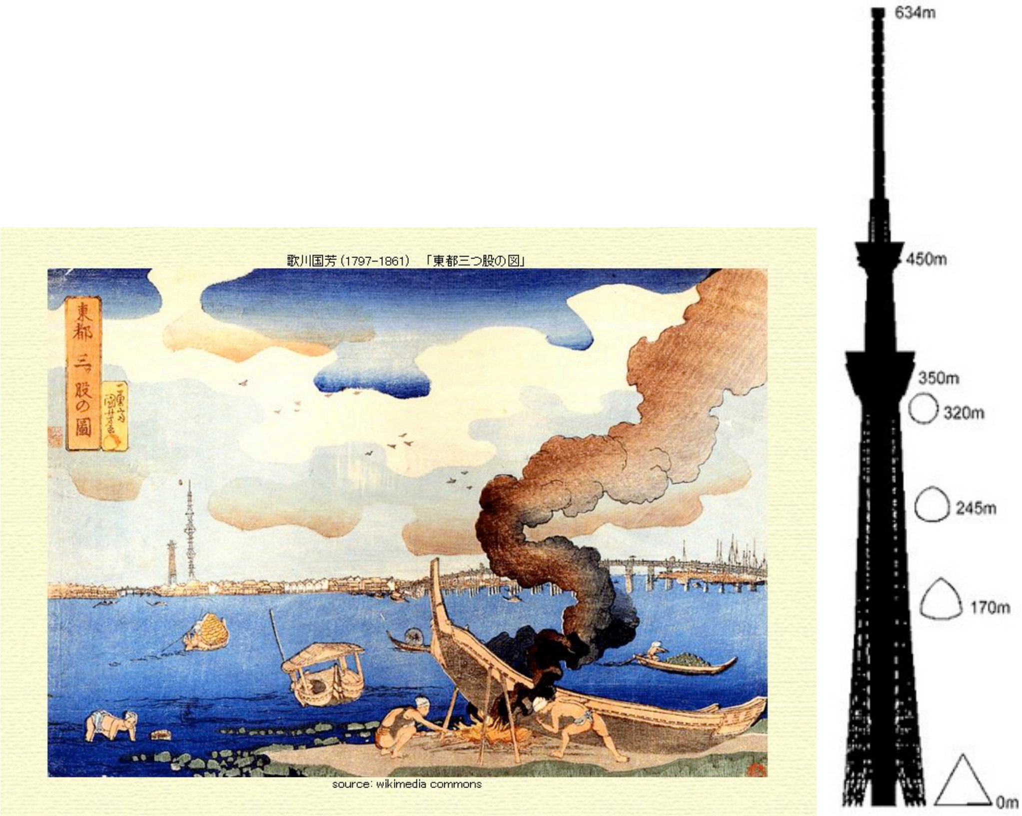

Figure 3. Kuniyoshi’s mysterious print and the varying shape of Tokyo Sky Tree.

There is a mysterious woodblock print by Utagawa Kuniyoshi (1797-1861), a famous Ukiyoe print artist of the Edo era. A strange tall imaginary tower is drawn in the scenery of Tokyo (Edo) more than 190 years before the Tokyo Sky Tree tower was built. No one can tell why he drew this.

A three-dimensional 1/40 scaled model of a wooden pagoda is commercially available, and it may help to practice building and understand the detailed design. It is made up of about 3,200 parts and costs 115,500 yen (about €1,100), and so is not 1/40 scaled in price!

The structure with the central pillar reminds us of some radio telescopes. The Parkes 64m Radio Telescope has a so-called "Master collimator" design for telescope pointing and drive. The telescope has in its center an instrument called a master collimator situated on an independent base, and the big antenna structure is servo controlled to this for precise pointing and drive. This novel design was adopted for the Nobeyama 45m telescope. The 45m telescope, dedicated in 1982, has a soft structure with so-called "homologous deformation" design and has achieved surface accuracy of 70 μm rms. The Usuda 64m antenna of ISAS also has the same master-collimator design.

It is not well understood who designed and built wooden pagodas in Japan in the 8th century. There are no individual masters known, like Daedalus in ancient Greek mythology. In the 8th century, Japan had some communications with China and Korea, and the technology may have evolved in Japan. There must have been a long feedback process to understand which design worked better, but the process surprisingly seems to have evolved quickly.

Buddhism started in India, and it was introduced to surrounding countries, and was adopted and evolved depending on the area. Temple, Pagodas, and above all, Buddhism itself has changed considerably. Buddhism and its expansion looks very like a supernova explosion.

2. Imaging Technology in Modern Radio Astronomy

On May 21, 2012, an annular solar eclipse was observed by radio telescopes in Japan. The radio heliograph at Nobeyama Radio Observatory has been regularly observing the sun simultaneously at 17 and 34 GHz. The sub-mm sun at 230GHz was observed by the 1.8m single dish of Osaka Prefecture University. In the microwave window the sun is much brighter than the moon and we can see only the eclipsed solar disk like the optical sun. But in sub-mm band, we can see both the sun and the moon simultaneously, and it is informative to show to the public.

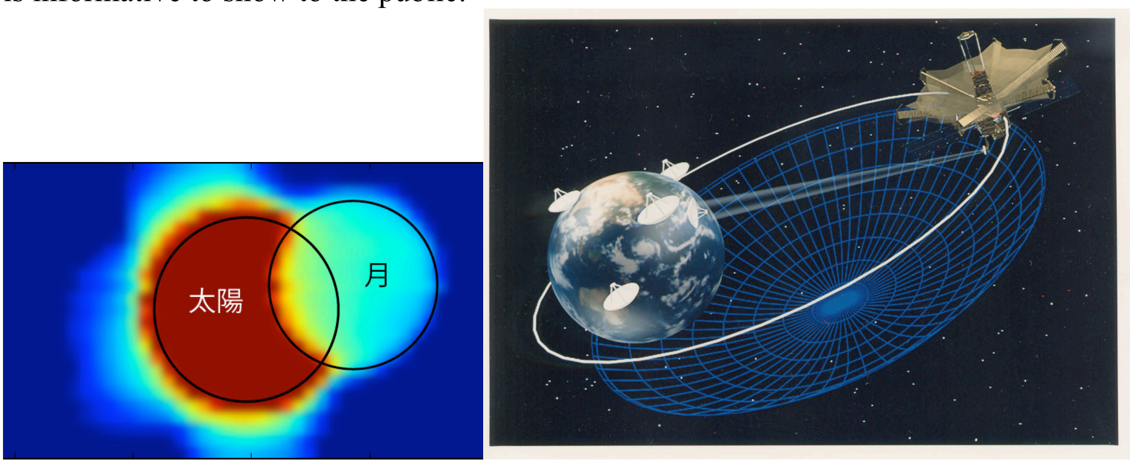

Figure 4. Sub-mm picture of the solar eclipse on May 21, 2012 (left), and cartoon of VSOP, first dedicated space-VLBI mission.

One extreme case for achieving very high angular resolution images is space-VLBI, which is the extension of ground based VLBI technology by adding radio telescopes in space. The test experiment was first realized by using a TDRSS satellite combined with Australian and Japanese telescopes in 1986 through 1988. And the dedicated radio astronomy satellite HALCA was launched in 1997 by ISAS to conduct space-VLBI observations. By the usage of the satellite orbit and earth rotation, good coverage of baseline length and orientation can be achieved to generate fine angular resolution images. After successful in-orbit checkouts the VSOP (VLBI Space Observatory Programme) project continued successfully with global collaboration.(Hirabayashi et al., 1998). A tracking station network, world wide ground radio telescopes, correlators, etc. were organized for the project. From Australia, for example, the Tidbinbilla tracking station, and major telescopes joined, and Tasso Tzioumis was an important collaborator during the mission. This was in nature one of the most complex space programs ever tried.

Figure 5. Greece and the International Space Station, as seen from Space Shuttle. The Peloponesse Peninsula and Kerastari is on the right. (Courtesy of JAXA)

It is interesting to understand that we have a long continuity of science and technology from ancient Greece. I would like to watch with the audience the whole of Greece from space as Icarus and Daedalus did more than 2,500? years ago.

References

Hirabayashi, H. et al, 1998, Science, 281,1825 and erratum 282, 1998