Subaru Reveals "Frameworks" of Galaxies at 11 Billion Years Ago (Forwarded)

Source: http://sci.tech−archive.net/Archive/sci.astro/2008−01/msg00232.html

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- *Date*: Sun, 20 Jan 2008 03:45:29 GMT

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December 18, 2007

Subaru Reveals "Frameworks" of Galaxies at 11 Billion Years Ago

A team of Japanese astronomers from the National Astronomical Observatory of Japan, Tokyo University, and Kyoto University in Japan obtained infrared and high−resolution images of galaxies from 11 billion years ago using the adaptive optics (AO) system and the infrared camera and spectrograph (IRCS) on the Subaru Telescope. Thanks to the removal of atmospheric blur by the AO system, high spatial resolution imaging was achieved in the near−infrared and the profiles of the distant galaxies were revealed (Fig. 1). The images of the distant galaxies show almost all of the galaxies have a light profile similar to the disk galaxies in the local universe.

In the local universe around our Milky Way galaxy, there are primarily two types of galaxies: elliptical and disk. Elliptical galaxies have stars that cluster in shapes ranging from nearly spherical to highly elongated, and disk galaxies have stars that make a spiral structure on a flattened disk shape (sometimes called "spiral galaxies", see Note 1). When, why, and how these galaxies in the local universe establish their current shapes are some of the biggest mysteries in astronomy. In order to answer these questions, it is important to observe galaxies as far away as possible, going back in time tracing their cosmic history examining their shapes and forms to determine their evolutionary profile.

Thus far, research with the Hubble Space Telescope (HST) has lead studies into the profiles of distant galaxies. HST observations have revealed that galaxies seen in the local universe are similar to the galaxies observed 8 billion years ago, and the elliptical and disk type galaxies prevail in both eras. The important next step in this study of distant galaxies is to examine shapes of galaxies even further away at an earlier time in the universe. Subaru found a galaxy at 12.9 billion years ago, which is the farthest object found so far, using the wide field imaging camera. However, the difficulty with looking ever deeper into space is that more distant galaxies have smaller apparent size and smaller actual size, making their profiles difficult to distinguish. In response to these hurdles, astronomers used the sophisticated instruments and state−of−the−art technology of the Subaru Telescope to explore into galactic realms billions of light years away.

In 2004, a team of Japanese astronomers from the National Astronomical Observatory of Japan, Tokyo University, and Kyoto University in Japan used the adaptive optics (AO) system and the infrared camera and spectrograph (IRCS) instrument on the Subaru Telescope to obtain infrared and high−resolution images of galaxies further than previously observed. Over a 12−month period, astronomers looked at 44 very faint objects within 13 fields of view. Their research was based on knowledge that galaxies consist of stars with various masses, sizes, and ages, and stars whose masses are similar to the Sun dominate the total masses of stars inside galaxies. The shapes of galaxies observed in the visible spectrum reflect their distribution of stars, and, therefore, astronomers think the shapes represent the "framework" of the galaxies (see Note 2). Consequently, studying the profiles of the galaxies in near−infrared light was necessary in order to reveal this "framework" due to the "red shift" effect of the expanding universe (see Note 3).

This galactic study obtained high spatial resolution near−infrared images of galaxies from 11 billion years ago. As a result, the profiles and "frameworks" of these very distant galaxies were revealed for the first time (Fig. 1). The results show the light distributions of the very distant galaxies have similar light profiles to the flatter disk galaxies in the local universe. Only one galaxy shows the light profile barely similar to the concentrated elliptical galaxies (Fig. 2). Considering the two types of galaxies seen in the local universe already exist in the universe 8 billion years ago, the initial findings showed that concentrated elliptical galaxies formed from the collision and merging of extended disk galaxies between 11 billion and 8 billion years ago. The profiles of the galaxies further away infer that the evolution of the galaxies is drastic between 11 and 8 billion years ago than the present and 8 billion years ago (Fig. 3).

Currently the AO observation is limited only for targets close to a local bright star. For the future, galaxies away from bright stars will be observed using the recently upgraded AO system with artificial laser guide star at the Subaru Telescope. It is expected that additional observations of large numbers of distant galaxies will further reveal their history and morphology, establishing their shapes and profiles seen in the local universe around our Milky Way.

The results were presented at the international conference "Panoramic Views of Galaxy Formation and Evolution" in which astronomers discuss topics related to the formation and evolution of galaxies based mostly on the observational results from Subaru Telescope. Additionally, the results will appear in the March 2008 issue of the Astrophysical Journal Supplement Series

Akiyama, M., Minowa, Y., Kobayashi, N., Ohta, K., Ando, M., Iwata, I., 2008, Astrophysical Journal Supplement Series, in press.

NOTES

Note 1: You can see the images of typical elliptical and disk galaxies from
Elliptical galaxy: http://www.nao.ac.jp/Subaru/hdtv/m87w_s.jpg (130KB)
Disk galaxy: http://www.nao.ac.jp/Subaru/hdtv/m63_s.jpg (121KB)

Elliptical galaxies have shapes ranging from nearly spherical to highly elongated, and disk galaxies have a flattened disk shape. Disk galaxies are sometimes called spiral galaxies. They have different light distributions: elliptical galaxies have concentrated light distributions which appear smooth and featureless, while disk galaxies have extended light distributions consisting of a flattened disk with stars forming a spiral structure.

Note 2: Visible light has a wavelength around 0.6 micron and can be detected with human eyes. Infrared and ultra violet light cannot be detected with human eyes. Infrared light have wavelength longer than 1.0micron, and ultra−violet light have wavelength shorter than 0.3 micron. The shapes of galaxies in visible light reflect the distribution of stars which dominate the total mass of galaxies. On the other hand, the ultra violet light of galaxies, which is dominated by heavier stars with shorter life time than the Sun, reflects only the area where currently stars are born inside the galaxies.

Note 3: The universe is thought to be expanding uniformly. As a result, more distant galaxies move away faster. If we observe a galaxy from Earth, the galaxy moving away faster will be observed in longer wavelength. We call this effect "redshift". Due to this redshift effect, the visible light from distant galaxies in the early universe is "shifted" to a longer wavelength and observed in the infrared. Consequently, ultra−violet light from a distant galaxy will shift and be observed in the visible wavelength.

IMAGE CAPTIONS:

[Figure1:
http://subarutelescope.org/Pressrelease/2007/12/18/fig01_e.jpg (3MB)]
Profiles and "frameworks" of galaxies from 11 billion years ago revealed by AO and IRCS at the Subaru Telescope. The high spatial resolution images are taken at the near−infrared light with wavelength of 2.0 micron. The white bar at the bottom right indicates the scale of 1 arcsec, which corresponds to 25,000 light years scale in the distant universe.

[Figure 2:
http://subarutelescope.org/Pressrelease/2007/12/18/fig02_e.jpg (1.5MB)]
These two figures show Indicator of Light Distributions of Galaxies as the

vertical axis and an Indicator of the Size of the Galaxies as the horizontal axis. The left figure shows the light distributions of the galaxies at 11 billion years ago. The figure on the right side shows simulation of how the galaxies at 5 billion years ago look like if we "bring" them back to 11 billion years ago, based on the images obtained with HST.

[Figure 3:
http://subarutelescope.org/Pressrelease/2007/12/18/fig03_e.jpg (3MB)]
This figure summarizes the observed evolution of the shapes of galaxies in the cosmic history. The disk galaxies observed at 11 billion years ago evolve into elliptical galaxies until 8 billion years ago through collision and merging of the galaxies. In the universe 8 billion years ago, there are elliptical− and disk−type galaxies, and it is thought that the evolution of the galaxies is much more milder between the present and 8 billion years ago than between 11 billion and 8 billion years ago.

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