Summary of Scientific Results - 2007

Subaru's journey of exploration utilizes the inherit quest for knowledge as the driving principle behind its mission to explore the Universe more deeply and comprehend nature more fully. As the universe continues to change and our understanding evolves accordingly, wondrous opportunities for discovery present themselves. Employing the latest technologies, we extended our gaze further and deeper into the sky towards the beginning of time, achieving results that were once considered science fiction.

During 2007, there were many astounding moments of discovery at the Subaru Telescope ranging from the smallest of micro-meteoroids flashing through our night sky to binary stars in nearby galaxies to the first mapping of dark matter. Let us briefly examine what some of those magical discoveries entailed.

Researchers evaluated the diameters of the heated tunnels left behind as meteors passed through the upper atmosphere. They estimated the meteors to be less than a millimeter in size and the typical column width of a meteor track as narrow as a few millimeters. This study was a bi-product of wide-field imaging observations and was the first time a meteor track column has been precisely measured using a physical analysis of the light emitted during the event. For the future, by focusing the Subaru Telescope to the altitude of the upper atmosphere where meteors disintegrate, highly detailed images of faint meteors can be collected to further the study of micro-meteoroids.

Outside the earth's atmosphere, Subaru monitored the demise of a comet as it broke into smaller and smaller pieces. Comet 73P/Schwassman-Wachmann 3 (SW3) was first discovered in 1930. In 1995, SW3 became exciting when the comet began breaking apart. When SW3 was observed again in 2000 it had further fragmented, and by the time the comet came around again in 2006, there were dozens of pieces. If the current collection of comet fragments remains stable, the team will continue to track them to understand the evolution of comet fragments and the gases and ices they contain. If the comet continues disintegrating some of those pieces may eventually become meteors.

While we're discussing comets, analysis of Subaru's observations of NASA's Deep Impact event (July 2005) showed that comet 9P/Tempel 1 consists of core material that has not metamorphosed since this comet left the Kuiper belt region beyond Neptune. This finding means that comets may maintain their central integrity even after numerous perihelion passages around the sun, which is important because cometary nuclei contain primordial dust and ice that existed when the solar system was first forming.

Subaru has a powerful wide-field camera mounted in the prime focus position called Suprime-Cam, and images of familiar objects provide discovery and insight into previously unseen phenomenon. A new image of the Crab Nebula (M1) supernova remnant was taken in March 2007, highlighting the beauty of stellar debris expanding away from the site of this ancient blast (first observed in 1054). The clarity and resolution of this image gives astronomers opportunities to study the mechanics of the expanding gas in the nebula in detail much greater than before.

Over the past several years, more and more planets have been discovered around nearby stars. Several months ago, a Japanese/US collaboration observed planetary system TrES-1, and measured the angle between the stellar spin axis and the planetary orbital axis to diagnose and discern the planet formation mechanisms. It was the third case for which the spin-orbit alignment has been measured, and importantly it is the faintest target (magnitude 12) to date. The team demonstrated for the first time that such measurements are possible for such a faint object, which is significant because most of the newly discovered transiting planets have relatively faint host stars. What is interesting about this system is that you have a Jupiter-sized planet that orbits very close to its star, much closer and faster than the planet Mercury in our solar system.

As planets are being discovered around nearby stars, stars are also being found around neighboring stars. In February 2007, an international research team obtained the first images of the second "sun" around the star gamma Cephei. This direct detection significantly improves our knowledge of the gamma Cephei system, such as the masses of the two stars and the minimum mass of their companion planet. Another research event later in the year collected an image of a young binary star system called XZ Tauri that revealed for the first time a jet of material streaming away from the pair's primary star. A previous observation showed a jet streaming from the secondary star; however, this new jet is offset by about 30 degrees from the secondary one. The discoveries suggest that each star could have a circumstellar disk with sites of planetary formation hidden inside. What is significant about binary star research is that binaries provide the best method for astronomers to determine the mass of distant stars. Additionally, because a large proportion of stars exist in binary systems, these stars help us understand the processes by which all stars form. The difficulty with studying these systems is that frequently the primary star occults the secondary one due to its brightness and/or the binary system located too far away to resolve clearly.

As the Subaru Telescope peered further a field, astronomers detected the heavy element thorium in a red giant star (COS82) within the Ursa Minor dwarf galaxy, a satellite of the Milky Way. Their discovery marks the first detection of thorium (232Th) in a star beyond the Milky Way, and follows the identification of thorium in more than ten stars within the Milky Way. What makes thorium important is that it is radioactive like uranium, and astronomers and can use these heavy elements to deduce the stars' ages, which may be millions or billions of years; this approach is called radioactive cosmochronometry. Other firsts included the discovery of an unusual streak of ionized hydrogen gas associated with Galaxy D100 located approximately 300 million light-years from Earth. The filament of gas is only 6 thousand light-years wide, yet extends 200,000 light-years, about the distance between the Milky Way Galaxy and its companion, the Large Magellanic Cloud. Finding such an extremely narrow and long ionized gas cloud is a first in astronomy. Other galactic research included a thorough inspection of a galaxy building block. Astronomers found that a small spheroidal dwarf galaxy named Leo II largely consists of older stars, a sign of survival through galactic cannibalism under which massive galaxies (i.e. Milky Way) consume smaller galaxies to attain their extensive size.

To close out the year, astronomers from Japan obtained deep field and high-resolution images of galaxies from 11 billion years ago. Their initial findings showed that concentrated elliptical galaxies formed from the collision and merging of extended disk galaxies between 11 and 8 billion years ago and that the evolution of the galaxies is much milder between the present and 8 billion years ago than between 11 and 8 billion years ago.

As our vision outward reached further back in time, an international team of astronomers created a three-dimensional map of the universe that provides the first direct look at the large-scale distribution of matter. This is the best evidence yet that “normal” matter, like stars and galaxies, accumulate along the densest concentrations of invisible dark matter. The map extends to a time when the universe was only half its current size and shows that dark matter has grown increasingly clumpy, forming long thread-like structures, the further away from the Big Bang.