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The Deep Impact Mission: New Paradigms in Early Solar System Formation

On July 4, 2005, the NASA Deep Impact mission impacted comet 9P/Tempel 1 at a velocity of 10.3 km / sec, and excavated nearly a million tons of dust in the process. A major world wide observing effort – both professional and amateur - complemented the event, the largest coordinated astronomy event we have ever had, involving over 80 professional observatories spread world-wide, and a large suite of Earth-orbital satellites. Prior to the selection of the comet 9P/Tempel 1 as the Deep Impact mission target, the comet was not well-observed. From 1999 up to encounter (July 4, 2005) and beyond there was an intensive world-wide observing campaign designed to obtain mission critical information about the target nucleus, including nucleus size, albedo, rotation rate, rotation state, phase function and the development of a dust and gas coma. The Deep Impact mission is unique in that it relies on an Earth-based (ground and orbital) suite of complementary observations of the comet just prior to impact and in the weeks following the impact as the activity develops and diminishes.

The spacecraft watched the development of the impact event during an 800 second fly by window, and obtained look back images of the nucleus. From these observations we have constrained the bulk density of the nucleus, the strength and porosity of the surface materials, as well as the thermal properties of the nucleus. I will summarize the pre-encounter observing plan and results, as well as the strategy for the world coordination at encounter and highlights of the Earth-based results. Earth based observers have built up a comprehensive picture of the impact which showed a gradual brightening of the comet as the dust was excavated from the crater, followed by a gradual decline to pre-impact brightness several days later. There was not a large activation of cometary activity as a result of the impact as seen from Earth. I will present the mission highlights from the spacecraft and the Earth campaign and the new paradigms for comet formation that the science team is discussing in light of these new results. In addition, I will share some new mission ideas that have been recently proposed that capitalize on the success of the Deep Impact mission.

Astrobiology - The Origin of Water on Earth

How does life begin and evolve? Is there life elsewhere in the Universe? What is the future of life on Earth and beyond? Today, NASA's Astrobiology Institute (NAI) is not only asking these age-old questions, it is actively seeking answers, and the new Astrobiology Institute lead team at the University of Hawaii is taking advantage of our unique island setting to understand the origin, history and evolution of water in the universe and its role in life. We humans, and all life on Earth, are aqueous beings.

Our cells are made mostly of a water solution packaged in membranes. The aqueous chemistry in these cells is responsible for growth, reproduction, and life. Water's chemical properties and the way it responds to changes in temperature make it an ideal medium for biological activity, so much so that it is considered essential for recognizable life. In addition to its direct role in biology, water is also a predominant determinant in the geology, geochemistry, and climate of our planet. It influenced the structure and early evolution of the solar system itself, aspects of which dictate the habitability of Earth. Water and life are connected on many scales, from the interstellar medium to microbial habitats, and through many processes, astrophysical, geological, geochemical, and biological. Water has been involved in life since its first appearance on the early Earth. The first three billion years of the drama of life on this planet was played out entirely in aquatic environments. Water is also involved in geochemical reactions that maintain surface conditions permissive of life. Cosmically, water is not uniformly abundant, and its incorporation into Earth-size planets is not necessarily constant. Because of the high abundance of water ice in the interstellar medium, water has played a vital role in physical and chemical processes that have lead to the formation of astrobiologically important molecules. Much of this material made its way into our solar system and may be preserved in comets and meteorites that we study today. An important debate in the understanding of the early Solar System concerns the origin of the Earth's oceans. The current ideas about the source of the water on Earth include delivery by comets and asteroids and accumulation from the planetesimals in-situ at the time the Earth formed. The D/H ratio for Earth oceans is enriched by a factor of 6.4 over the protosolar value of 2.5x10-5, and it has been believed that delivery of water by comets, which have a D/H ~ 30x10-5 (three measurements) may have contributed to this enrichment. Dynamical models of terrestrial planets formation suggest that Mars-sized planetary embryos might deliver sufficient water to the Earth from the asteroid belt, and that the fractional cometary contribution might be small. However, this is not consistent with Earth noble gas abundances. D/H measurements have been made for comets likely originating in the same part of the solar nebula. It is expected that there might be a different D/H ratio for comets formed at different distances within the solar nebula. In addition, the standard against which the cometary D/H is measured, ocean water, may have changed over time because of various fractionation processes and would not represent Earths primordial water. I will discuss research we are conducting to address the question of the origin of Earth's water, from new comet measurements, to solar nebula models to a geophysics program to look at the D/H ratios in deep mantle xenoliths recovered from Iceland and Hawaii.