Hello Mars, goodbye Hubble?

Successes at Mars make the promise of more money for space exploration appealing, but will other projects pay the price? Peter Bond reports.

1: This image, in approximate true colour, was taken by the panoramic camera onboard the Mars Exploration Rover Spirit. It shows a football-sized rock called Adirondack, made of basalt containing olivine, pyroxene and magnetite.
surprise, the particles did not become steadily more numerous as the spacecraft approached Wild 2, but rather increased in sheets and swarms, separated by sparse patches.

Stardust has now begun its two-year, 1.14 billion km trek back to Earth. The sample return capsule is scheduled to land on 15 January 2006, when it will be taken to Johnson Space Center. The spacecraft’s navigation camera also produced some of the best images ever taken of a comet’s nucleus, including five jets of material spewing out from the 5 km wide nucleus, and where they originated on the surface. Wild 2 was revealed as a rounded snowball marked by deep pits – very different from the nuclei of comets Borrelly and Halley. Its old-looking surface and the apparent spherical shape suggest that Wild 2 formed directly from the dust and gas of the pre-solar disk, rather than being chipped off a larger body by an impact (stardust.ipl.nasa.gov).

**Goodbye Hubble?**

Within days of the President’s visionary speech in January, NASA administrator Sean O’Keefe announced the cancellation of SM4, the final Hubble Space Telescope (HST) servicing mission. The controversial decision was said to be based upon safety concerns and the new directive to retire the shuttle by 2010, although funding considerations undoubtedly played a part. The decision means that an advanced camera and spectrograph – both already built – will not be installed. It also leaves the HST’s continued operation at the mercy of its ageing gyroscopes, batteries and other equipment, and casts a shadow over the futures of employees at the Space Telescope Science Institute in Baltimore. Based on past performance, engineers believe the observatory has a reasonable chance of remaining in operation until 2007, at least four years before the launch of its successor, the James Webb Space Telescope.

Not everyone accepted the decision. By late January, O’Keefe felt obliged to backtrack a little by asking Admiral Hal Gehman, Chair of the Columbia Accident Investigation Board, to “review the matter and offer his unique perspective”. The fate of the two new instruments scheduled for installation during SM4 is currently uncertain. There is some discussion about the possibility of launching them on Explorer-class missions. The question of how to end the working life of the HST in a controlled manner also remains unanswered (www.stsci.org/SM_cancellation.html).

As if to emphasize the value of HST, recent weeks have seen groundbreaking results from the HST in a variety of astronomical fields: the first detection of oxygen and carbon in the atmosphere of a planet beyond our solar system; the most distant galaxy yet; and the “dark ages” of the universe has been demonstrated by the discovery of what seems to be the most distant galaxy known. At an estimated 13 billion light years away, the object is being viewed at a time only 750 million years after the Big Bang, when the universe was barely 5% of its current age. The primeval galaxy was identified by combining HST and Keck telescope observations of a cosmic gravitational lens and first detected in a long exposure of the nearby cluster of galaxies Abell 2218, taken with the HST’s Advanced Camera for Surveys (ACS). HST images show that the object has a redshift of 6.6 to 7.1, making it the most distant source currently known, although long exposures on the 10 m Keck telescopes suggest a redshift of around 7 (hubblesite.org/news/2004/08).

The ACS has also played a role in studies of two distant galaxy clusters, confirming that galaxies formed quite early in the history of the universe. The two clusters studied are respectively the most distant proto-cluster ever found and the most massive known galaxy cluster for its epoch – and they look very like galaxy clusters seen today. The ACS was used to observe the massive cluster RDCS1252.9-2927 and the proto-cluster TNJ1338-1942, while the Chandra X-ray observatory yielded the mass and heavy element content of RDCS1252.9-2927, as it transited its parent star found an extended ellipsoidal envelope of oxygen and carbon surrounding the planet. The team led by Alfred Vidal-Madjar (Institut d’Astrophysique de Paris) believes that these atoms are swept up from the lower atmosphere in the flow of the escaping atmospheric atomic hydrogen. “We speculate that even heavier elements such as iron are blown off at this stage as well,” said team member Alain Lecavelier des Etangs.

Some astronomers speculate that this evaporation mechanism may be so overwhelming that planets orbiting even closer to their parent star may eventually become merely solid remnants of “evaporated gas giants”. The term “chthonian planets” has been suggested for this proposed new class of extrasolar planets – a reference to Greek deities from the infernal underworld. These results were published in Astrophysical Journal Letters. HD 209458b was already famous as the first extrasolar planet discovered transiting its star, the first with an atmosphere, and the first observed to have an evaporating hydrogen atmosphere. Since it orbits only 7 million km from its yellow Sun-like star, its surface is about 1000 °C (sci.esa.int/hubble).

**Distance records**

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Space shorts

● ELEMENTAL ANTENNAE. The Chandra X-Ray Observatory has discovered rich deposits of neon, magnesium and silicon in a pair of colliding galaxies known as the Antennae. When the clouds in which these elements are present eventually cool, an exceptionally high number of stars with planets should form. These results may foreshadow the fate of the Milky Way and its future collision with the Andromeda Galaxy. Collisions between huge gas clouds in the galaxies probably triggered a stellar baby boom. The most massive of these stars race through their evolution in a few million years and explode as supernovae. Heavy elements manufactured inside these stars are blown away by the explosions and enrich the surrounding gas over thousands of light years. According to a report in Astrophysical Journal Letters, Chandra revealed regions of varying enrichment in the galaxies – in one cloud magnesium and silicon are 16 and 24 times more abundant than in the Sun.

● X-RAY HALOS. An international team led by Simon Vaughan (University of Leicester) has discovered a unique phenomenon: a series of expanding X-ray halos surrounding a γ-ray burst (GRB). ESA’s Integral γ-ray observatory detected the 30-second long GRB031203 on 3 December 2003 and the halos were discovered in a follow-up observation with XMM-Newton that started 6 hours after the burst. The spacecraft’s cameras revealed two rings centred on the fading X-ray afterglow from the GRB. The GRB lies behind the plane of our galaxy, so its light has to travel through the gas and dust in the galactic disc to reach us. X-rays from more distant dust reach us later, giving rise to the appearance of expanding rings. By measuring the expansion rate of the halos, the team determined that they are due to thin sheets of dust 2900 and 4500 light years away. The distances have an uncertainty of just 2%, a remarkable level of accuracy for a remote object in our galaxy. The nearest dust sheet is 2900 light years away. The distances have an uncertainty of just 2%, a remarkable level of accuracy for a remote object in our galaxy. The nearest dust sheet is 2900 light years away.

2: Galaxy cluster Abell 2218 is acting as a powerful lens, magnifying all galaxies lying behind the cluster core. The lensed galaxies are all stretched along the cluster’s centre and some of them are multiply imaged. Those multiple images usually appear as a pair of images with a third – generally fainter – counter image, as is the case for the very distant object. (ESA, NASA, J-P Kneib (Caltech/Observatoire Midi-Pyrénées) and R Ellis (Caltech).)

2927. Both studies led the astronomers to conclude that these systems are the progenitors of the galaxy clusters seen today.

The first HST study – published in the 20 October 2003 issue of the Astrophysical Journal – estimated that the bulk of the stars in RCD9522 formed more than 11 billion years ago (redshifts greater than 3). The second paper uncovered, for the first time, a proto-cluster of “infant galaxies” that existed more than 12 billion years ago (redshift 4.1). These small galaxies, grouped around one large galaxy, are so young that astronomers can still see stars forming within them. These results were published in the 1 January issue of Nature (hubble.esa.int/).

Assault and battery

By observing the universe at different wavelengths, astronomers have been able to study how a galaxy disintegrates. Once a spiral like our Milky Way, galaxy C153 is now plunging through the heart of a distant cluster of galaxies, creating streams of searingly hot gas that extend 200 000 light years into space. In this unusually violent collision with ambient cluster gas, the galaxy is stripped down to skeletal spiral arms as it loses fresh hydrogen for new stars. The first suggestion of something amiss in C153 came in 1994 when the Very Large Array found an unusually high number of radio galaxies; C153 also stood out as an exceptionally powerful radio source. This inspired a team led by William Keel (University of Alabama) to investigate further. X-ray observations from ROSAT demonstrated that vast amounts of gas at 20 million K envelop the galaxies. The gas is concentrated into two regions, suggesting two galaxy clusters in collision. Subsequent ground-based studies found many star-forming systems and active galactic black holes.

The HST showed that C153 appeared unusually clumpy with many young star clusters and chaotic dust features, including a “tail” of gas. The observations showed that the light in the tail can be mostly attributed to recent star formation, providing a direct link to the stripping of the galaxy as it passed through the cluster core. Evidence of recent star formation also came from an optical spectrum obtained at the Gemini North telescope. Meanwhile, the Mayall telescope found a very long tail of extended gas that was apparently generated in part by stellar winds boiling off the new star birth regions and being blown backwards as the galaxy streaked through the surrounding hot gas. Spectroscopic observations showed that 90% of C153’s blue light is from stars born 100 million years ago, when the galaxy was careering through the densest gas in the cluster core. They also showed that, although the stars orbit the galactic centre, multiple clouds of gas are moving independently. Finally, the Chandra X-ray Observatory discovered that the cooler clouds detected with optical telescopes are embedded in a much larger multimillion-degree trail of gas. Chandra’s data indicate that this hot gas was probably enriched in heavy elements by the starburst and driven out of the galaxy by its motion through the much larger gas cloud that pervades the cluster.

Collectively, these observations offer evidence that the ram pressure of external gas in the cluster is stripping the gas from the galaxy. Eventually, C153 will lose the last of its spiral arms and become a bland S0-type galaxy with a central bulge and disk. These types of galaxies are common in dense galaxy clusters seen today. The results were presented at a recent meeting of the American Astronomical Society.

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