National Aeronautics and
Space Administration

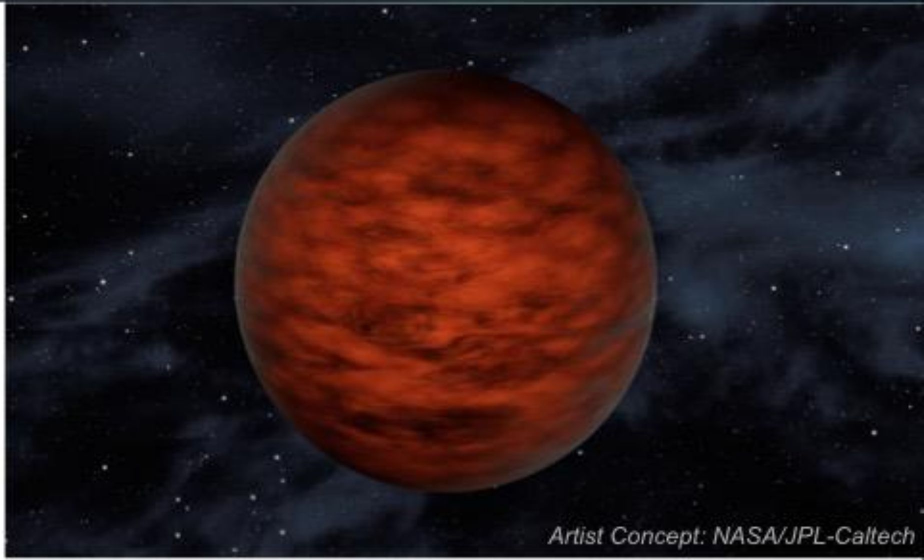
Science Mission Directorate

Weekly Highlights

April 29, 2016

Lone Planetary-Mass Object Found in Family of Stars

Associated paper accepted for publication in The Astrophysical Journal

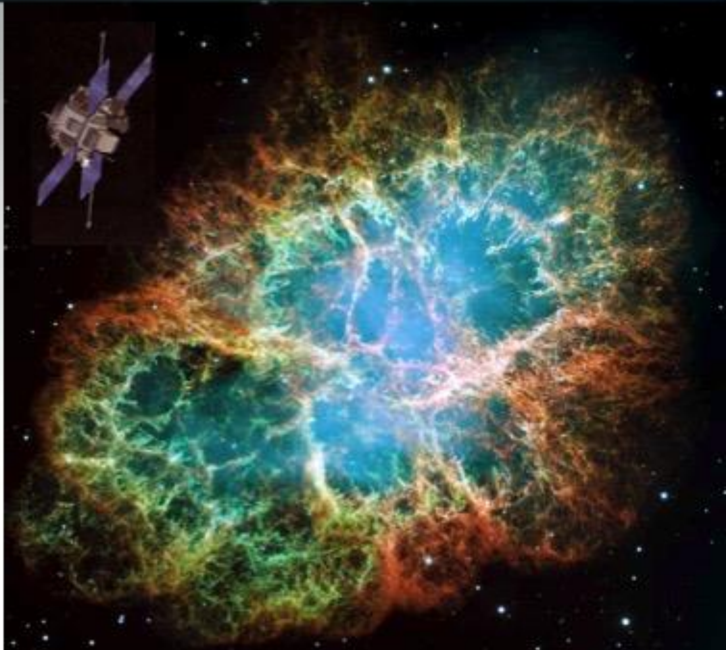

Artist Concept: NASA/JPL-Caltech

- Scientists have identified a free-floating, planetary-mass object within a young star family, called the TW Hydrae association, using data from NASA's Wide-field Infrared Survey Explorer, WISE, and the Two Micron All Sky Survey, or 2MASS. The newfound object is called WISEA J114724.10-204021.3, or just WISEA 1147 for short.
- WISEA 1147 is one of the few free-floating worlds where astronomers can begin to point to its likely origins as a brown dwarf and not a planet. Because the object was found to be a member of the TW Hydrae family of very young stars, astronomers know that it is also very young -- only 10 million years old. And because planets require at least 10 million years to form, and probably longer to get themselves kicked out of a star system, WISEA 1147 is likely a brown dwarf. Brown dwarfs form like stars but lack the mass to fuse atoms at their cores and shine with starlight.
- Of the billions of possible free-floating worlds thought to populate our galaxy, some may be very low-mass brown dwarfs, while others may in fact be bona fide planets, kicked out of nascent solar systems. At this point, the fraction of each population remains unknown. Tracing the origins of free-floating worlds, and determining whether they are planets or brown dwarfs, is a difficult task, precisely because they are so isolated.
- Astronomers found WISEA 1147 by sifting through images taken of the entire sky by WISE, in 2010, and 2MASS, about a decade earlier. They were looking for nearby, young brown dwarfs. One way to tell if something lies nearby is to check to see if it's moved significantly relative to other stars over time. The closer an object, the more it will appear to move against a backdrop of more distant stars. By analyzing data from both sky surveys taken about 10 years apart, the close objects jump out.
- Finding low-mass objects and brown dwarfs is also well suited to WISE and 2MASS, both of which detect infrared light. Brown dwarfs aren't bright enough to be seen with visible-light telescopes, but their heat signatures light up when viewed in infrared images. The brown dwarf WISEA 1147 was brilliantly "red" in the 2MASS images (where the color red had been assigned to longer infrared wavelengths), which means that it's dusty and young.
- After more analysis, the astronomers realized that this object belongs to the TW Hydrae association, which is about 150 light-years from Earth and only about 10 million years old. That makes WISEA 1147, with a mass between about five and 10 times that of Jupiter, one of the youngest and lowest-mass brown dwarfs ever found.

NASA's Heliophysics Mission, ACE, Reveals the Supernova Origins of Galactic Cosmic Ray Particles

W. R. Binns, et al. (2016) Observation of the ^{60}Fe Nucleosynthesis-Clock Isotope in Galactic Cosmic Rays. *Science*, 10(1126)

Most of the galactic cosmic rays that we detect at Earth originated relatively recently in nearby clusters of massive stars, according to new results from NASA's Advanced Composition Explorer (ACE) spacecraft. Cosmic rays are high-speed atomic nuclei with a wide range of energy - the most powerful almost as fast as the speed of light. Earth's atmosphere and magnetic field shield us from less-energetic cosmic rays, which are the most common. However, cosmic rays will present a hazard to unprotected astronauts traveling outside of Earth's magnetic field.



Credits: NASA/ESA/Arizona State University

The extremely rare cosmic rays that are the subject of a paper published in Science – the radioactive isotopes of iron, ^{60}Fe - come from outside our solar system but within our Galaxy and are a species of galactic cosmic rays. ^{60}Fe is created inside massive stars when they explode in a supernova, and is then set free into space. Shock waves from that explosion or subsequent supernovae accelerate it to near light speed. Although these rays zip through space, they don't travel very far because they can't travel in a straight line. Because they are electrically charged, they are forced to take convoluted paths along the tangled magnetic fields that make up our galaxy. And, due to their radioactive nature, they have a relatively small half-life time of only 2.6 million years.

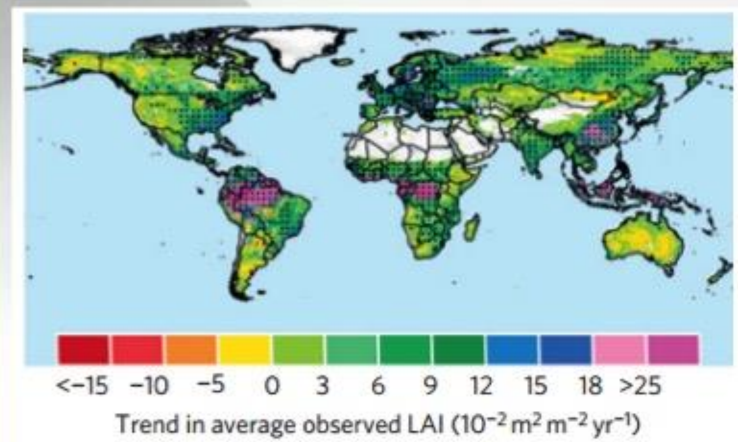
Therefore, the fact that ACE has detected these particles near Earth at all means that they couldn't have originated from very far away and that there was a supernova a few million years ago in our part of the galaxy. Previous studies of ACE measurements of different cosmic ray isotopes determined that there exists a time lag between when the isotopes are created and when they are accelerated. That means that the particles must have been created in one supernova and then accelerated by the shock wave from a second nearby supernova. This evidence narrows down the potential birthplace of these particles to be in clusters of massive stars, called OB associations, where supernovae occur often enough to have first given birth and then accelerated these young particles into cosmic-ray speeds. Particularly, there are more than 20 OB associations in a close enough radius to Earth – a few thousand light years – that would explain the detection of ^{60}Fe. Many scientists believe that the most likely birthplace for these rare rays is in the subgroups of the nearby Scorpius and Centaurus constellations. Before we received this data, we were in the dark regarding where this radiation came from and how long it's been with us. The ACE data have allowed us to focus in on a clearer picture, giving us a more detailed understanding on the origins of the galactic cosmic rays in our solar system, and how they were formed.

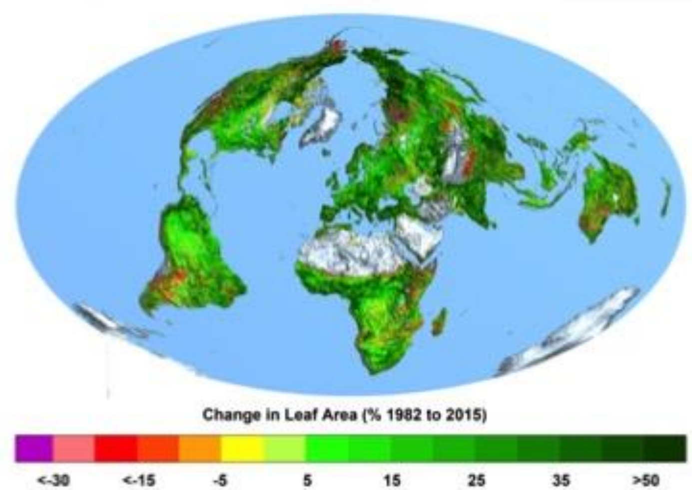
The Heliophysics ACE mission plays a vital role in space weather prediction for the nation. Launched in 1997, its sophisticated instrument suite continues to contribute to our understanding of the origin of the solar wind, of solar energetic particles and of cosmic rays.

Greening of the Earth and its Drivers

Zhu, Zaichun et al.| Nature Climate Change | April 2016 | doi: 10.1038/nclimate3004

NASA funded scientists and international collaborators showed a persistent and widespread increase of the growing season integrated leaf area index (LAI) (greening) over 25% to 50% of the global vegetated area, using data from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) and NOAA's Advanced Very High Resolution Radiometer (AVHRR) satellite sensors for the past 35 years. Factorial simulations with multiple global ecosystem models suggested that CO2 fertilization effects explain 70% of the observed greening trend, followed by nitrogen deposition (9%), climate change (8%) and land cover change (LCC) (4%). The study showed that CO2 fertilization effects explain most of the greening trends in the tropics, whereas climate change has resulted in greening of the high latitudes and the Tibetan Plateau. LCC has contributed most to the regional greening observed in southeast China and the eastern United States. Global environmental change is rapidly altering the dynamics of terrestrial vegetation, with consequences for the functioning of the Earth system and provision of ecosystem services. Yet how global vegetation is responding to the changing environment is not well established. The regional effects of unexplained factors suggest that the next generation of ecosystem models will need to explore the impacts of forest demography, differences in regional management intensities for cropland and pastures, and other emerging productivity constraints such as phosphorus availability.

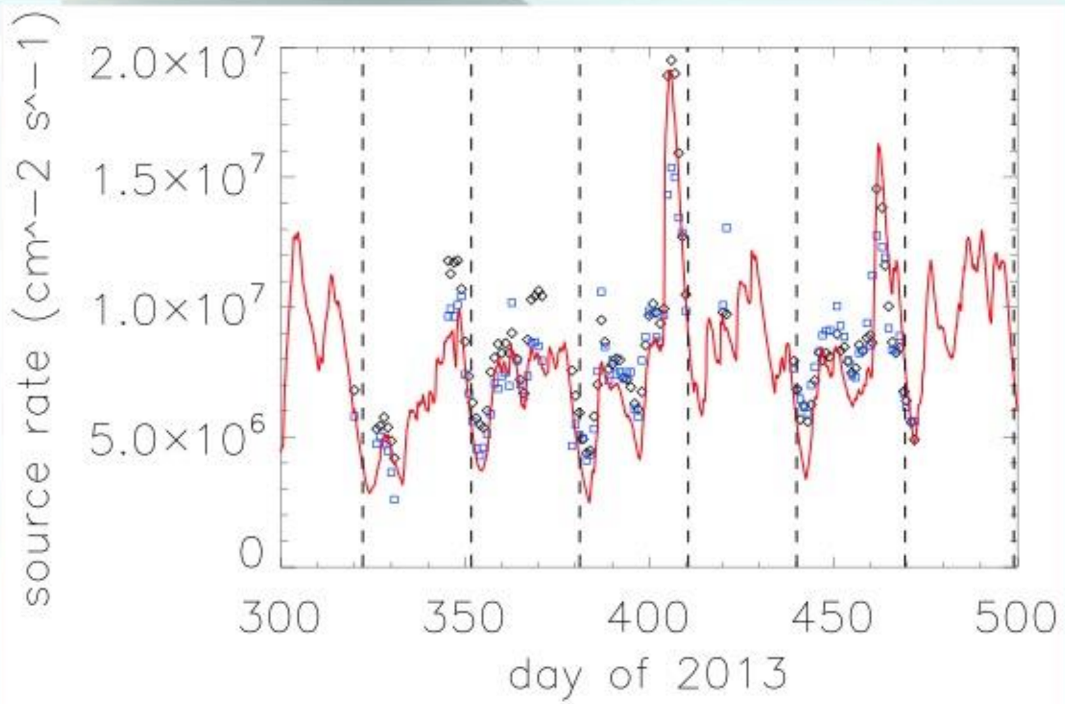




Helium in the Moon's Exosphere Measured by Three Different Spacecraft Show Remarkable Agreement

Helium observations from three different missions were made in conjunction with each other for a period of 200 days:

- LADEE Neutral Mass Spectrometer (NMS) detected helium atoms in situ at spacecraft altitude.
- LRO Lyman Alpha Mapping Project (LAMP) detects the column density of helium below the spacecraft.
- ARTEMIS detects the incoming alpha (He^{++}) particle flux through the electrostatic analyzer.



LAMP (blue), LADEE (black), and ARTEMIS (red) data displayed as helium source rate as a function of time over the entire LADEE mission agree in magnitude and in variability. These are three very different observation techniques with remarkable agreement.

- By modeling the lunar helium exosphere, polar observations from the LAMP instrument could be compared to the LADEE equatorial observations. Then, using the flux from ARTEMIS in the Monte Carlo model reproduces the temporal variations that were observed in helium density.
- By analyzing the results from these three complementary measurements, it was determined that Helium in the Moon's atmosphere is primarily derived directly from helium ions in the solar wind (64%). The remainder is temporally disassociated from the solar wind flux and either comes from outgassing of radiogenic helium from the Moon itself or slow diffusion of implanted solar wind helium in the soil.
- These results give confidence that scientists understand how the lunar atmosphere operates.

Hurley, D. M. et al. (2015), *Icarus.*

Rocky Run Middle School "Sixth Annual Science Fair" at the Children's Science Center in Fair Oaks Mall, VA

Rocky Run students listen to STEM guest speakers

On April 7, 2016, the Rocky Run Middle School of Fairfax, Virginia held it's "Sixth Annual Science Fair" at the Children's Science Center in Fair Oaks Mall, VA. Approximately 175 students and family attended the STEM family fun night which included several speakers. NASA's Deputy Chief Scientist, Dr. Gale Allen spoke about:

- NASA's Science Directorate missions and gave examples
- NASA's Journey to Mars Communications Campaign
- Models available for viewing Mars Science Laboratory – Curiosity and Ceres
- Outreach materials were distributed to students and family