Sun-Grazing Comet Flies Deep Into Solar Corona, Adding Fidelity To Existing Solar Magnetic Field Models

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PALO ALTO, Calif., June 10, 2013 /PRNewswire/ -- On December 15-16, 2011, a Sun-grazing comet, designated Lovejoy (C/2011 W3), passed deep within the hot solar atmosphere – the corona – effectively probing a region that could never be visited by spacecraft because of the intense heat radiating from the nearby solar surface. In a paper published today in the journal *Science*, researchers from several institutions – including the Solar & Astrophysics Lab at the Lockheed Martin (NYSE: LMT) Advanced Technology Center (ATC) in Palo Alto, Calif. – have analyzed extreme-ultraviolet observations (EUV) from three sun-watching spacecraft and identified characteristics of the embedded magnetic fields through which the comet passed.

"The corona shapes most of the space weather storms that impact Earth," said Dr.Karel Schrijver of the Lockheed Martin ATC, co-author of the *Science* paper, and principal investigator of the Atmospheric Imaging Assembly (AIA) onboard NASA's Solar Dynamics Observatory (SDO). "The only part of the corona that we can study with observatories is the part we can see.

"Comet Lovejoy flew through the corona down to a height of only 10% of the solar diameter, where there is almost nothing that we can image," continued Schrijver. "It is essentially an ultra high vacuum with a density even lower than where the International Space Station orbits Earth. But when Lovejoy flew through, material from its warming surface evaporated, forming a tail that then lit up brightly enough to be observed. The wiggling of its direction and the changes in intensity and persistence of that tail allowed us to map the otherwise invisible magnetic field. This provided substantial insight into this very dynamic region that could never be probed before. What we hope to learn eventually is how the Sun's magnetic field is distorted as it becomes part of the solar wind that blows past all the planets, and thereby to better predict when violent solar eruptions threaten Earth's space environment."

The observations of Lovejoy during its passage were made by the extreme ultraviolet telescopes of AIA on SDO, along with other telescopes on the twin spacecraft of NASA's Solar Terrestrial Relations Observatory (STEREO). This opportunity to observe Lovejoy from multiple perspectives provided researchers with a unique data set that enabled them to make inferences about the complex magnetic fields through which the comet traveled.

To better understand the signature of the comet's passage, a state-of-the-art magnetohydrodynamic (MHD) model of the solar corona was employed, combined with a prescription for how the cometary tail gases would behave in the extremely hot environment with temperatures of several million degrees.

"The apparent 'wiggles' out of the orbital path observed by SDO and STEREO gave us partial information on the local direction of the magnetic field," said lead author Dr. Cooper Downs of Predictive Science Incorporated in San Diego. "Combined with our computer model, this enabled us to map the magnetic field along the comet's trajectory while also confirming our model field for the distant surroundings. SDO AIA observations show that the comet tail motion was neither aimed directly away from the Sun, which one would expect if the tail were caught only in the solar wind or driven by the pressure of the intense light, nor did the tail simply fall away behind the comet in its orbit, which would be expected if the solar wind and the solar magnetic field had no influence at all. The tail motions that we observed reveal the pattern of the magnetic field within the solar corona, which enabled us to demonstrate that our magnetic field model agrees quite closely with the Sun's invisible magnetic field."

The *Science* paper published today – entitled "Probing the Solar Magnetic Field With a Sun-Grazing Comet" – is co-authored by John A. Linker, Zoran Mikic and Pete Riley of Predictive Science Incorporated, Carolus J. Schrijver of the Lockheed Martin Solar & Astrophysics Laboratory at the ATC in Palo Alto, and Pascal Saint-Hilaire from the Space Science Laboratory at the University of California, Berkeley.

The ATC-built Extreme Ultraviolet Imager (EUVI) instrument is one element of an instrument suite on each STEREO spacecraft called SECCHI – the Sun-Earth Connection Coronal and Heliospheric Investigation. The Atmospheric Imaging Assembly on SDO was also designed and built at the ATC.

The ATC is the research and development organization of Lockheed Martin Space Systems Company and creates the technology foundation for the company's business. In addition, the ATC conducts research into understanding and predicting space weather and the behavior of the Sun, including its impacts on Earth and climate. It has a five-decade-long heritage of spaceborne instruments.

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