Physicist develops new model for speed and motion of solar flares

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MSU solar physics post-doctoral researcher Sean Brannon will speak at the Solar Physics Division conference about his research on solar flares. MSU photo by Kelly Gorham

A Montana State University physicist who has developed a new model that predicts the speed of solar plasma during solar flares, likening it to the path traveled by a thrown baseball, will present his findings at the Solar Physics Division of the American Astronomical Society conference being held this week in Boulder, Colorado.

Sean Brannon, a postdoctoral researcher in the MSU Department of Physics within the College of Letters and Science, developed the model that might help to define how solar flares evolve and provide better ways to predict them. His work could have applications on how to protect power grids and communication technology and aeronautics from the energy released by the flares.

Brannon used data from the NASA Interface Region Imaging Spectrograph satellite, also known as IRIS, which monitors a specific layer of the sun known as the transition region. The transition region is thin, but complex, and separates the sun's outermost layer, the corona, from an inner layer, the chromosphere. The corona, the chromosphere and the transition region are of great interest and mystery to scientists.

Temperatures in the corona can reach several million degrees Kelvin, far hotter – often by more than a factor of 100 – than any other layer of the sun's atmosphere. A solar flare arcing through the corona can be more than 10 million degrees Kelvin. This is puzzling and seems counterintuitive since the corona is the furthest layer from the sun and, therefore, should arguably be the coolest.

IRIS spectrograms are made by a process similar to what happens when you shine light through a prism, breaking it into different colors. Each color is formed by a different kind of atom in the solar atmosphere and we can extract all kinds of interesting information about what the plasma is doing based on that spectrum. For example, if the light is more red or blue than we'd expect, then we know that the plasma is moving either away from or toward us," Brannon said.

Brannon used IRIS's data to look at the sun's solar flare process. During a solar flare, plasma from the sun can heat up to millions of degrees Kelvin and evaporate into the corona. There it fills or is funneled into powerful magnetic fields that give it an arcing, loop-like shape, Brannon said.

"We then expect that this hot plasma will cool off over the next several minutes to hours. As it cools, models predict that it should start to drain back out of the loops, resulting in spectral signatures that should be detectable," Brannon said.

"Up until now, however, there haven't been any published papers analyzing an observation of the entire filling, cooling, and draining process, nor have there been any papers that attempt to model a spectral observation as a signature of the draining," Brannon said. "The cooling and draining is important to look at, since we'd like to be sure that the plasma we're measuring is evaporated plasma draining back, and not some other source of plasma."

Brannon devised a simple model to describe the speed at which a blob of plasma falls from the top of an oval-shaped flare loop and how it would appear on an IRIS spectrograph. His results indicate that plasma is draining from the loops at free-fall speeds – similar to the path a baseball follows when thrown. Additionally, the location and timing of the draining plasma matches that which was observed evaporating.

The prediction of large solar flares is important because they can emit vast amounts of energy that can disrupt power grids, satellites, communication technology and aeronautics. For example, in March 1989, a powerful solar flare left millions of Canadians without electricity for about 12 hours, according to NASA.

"The sun really dominates Earth's environment, climate and space in which Earth lives," Brannon said. "What the sun does can have very profound impacts on life here on Earth. So, understanding the sun's processes can help us determine how to protect technology and people."

MSU Physics Professor Dana Longcope was Brannon's academic adviser and is national chairman for the Solar Physics Division. Longcope said that while solar flares are unpredictable making it difficult to find one to observe, Brannon was able to identify a specific IRIS observation, enabling him to make his analysis.

"He came up with a very different interpretation of what happens during a solar flare," Longcope said. "It is one of the most compelling quantitative observations I've seen as to what we'd expect to see during a solar flare. It's a credit to a scientist when they look at the data and they aren't blinded by what they expect to see, but rather keep an open mind and observe what is actually happening."

Provided by Montana State University

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