Breakthrough method for predicting solar storms

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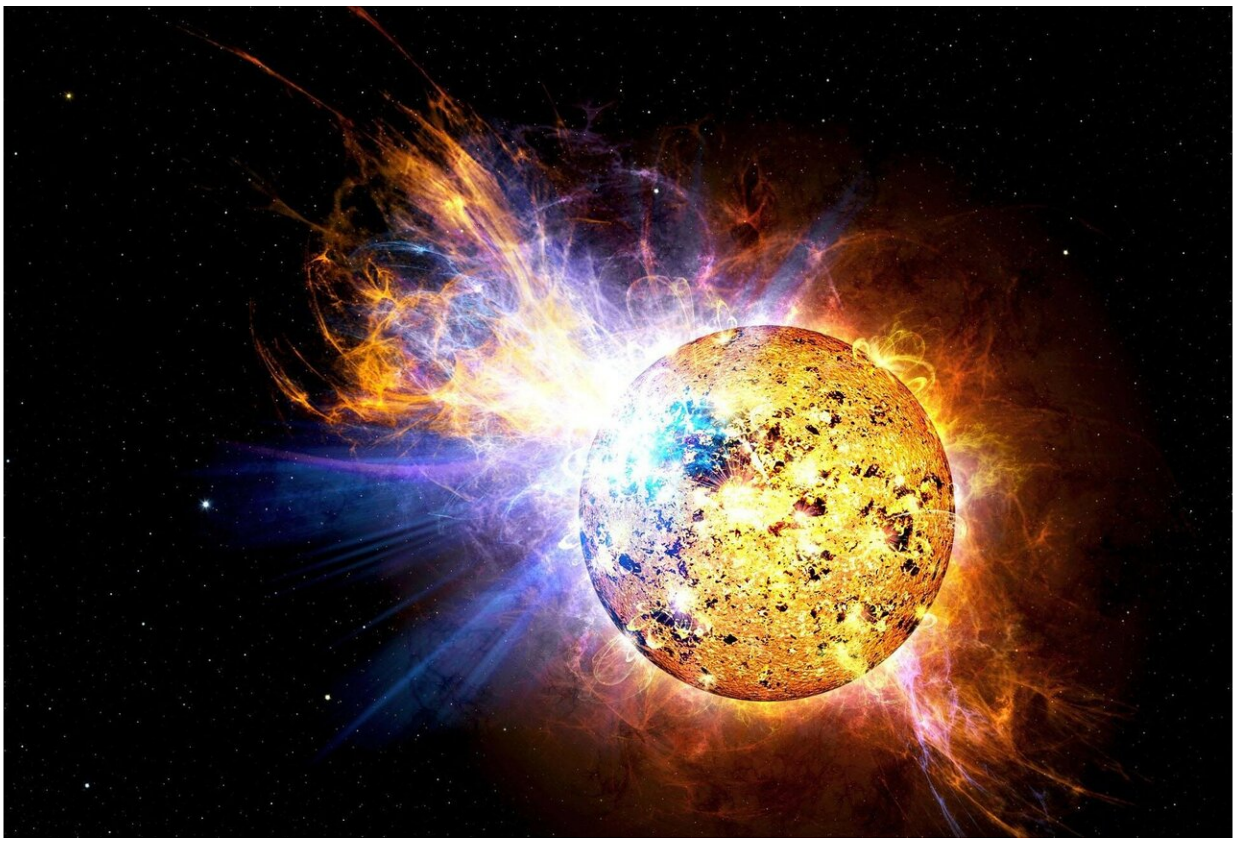

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Extensive power outages and satellite blackouts that affect air travel and the internet are some of the potential consequences of massive solar storms. These storms are believed to be caused by the release of enormous amounts of stored magnetic energy due to changes in the magnetic field of the sun's outer atmosphere—something that until now has eluded scientists' direct measurement. Researchers believe this recent discovery could lead to better "space weather" forecasts in the future.

"We are becoming increasingly dependent on space-based systems that are sensitive to space weather. Earth-based networks and the electrical grid can be severely damaged if there is a large eruption," says Tomas Brage, Professor of Mathematical Physics at Lund University in Sweden.

Solar flares are bursts of radiation and charged particles, and can cause geomagnetic storms on Earth if they are large enough. Currently, researchers focus on sunspots on the surface of the sun to predict possible eruptions. Another and more direct indication of increased solar activity would be changes in the much weaker magnetic field of the outer solar atmosphere—the so-called Corona.

However, no direct measurement of the actual magnetic fields of the Corona has been possible so far.

"If we are able to continuously monitor these fields, we will be able to develop a method that can be likened to meteorology for space weather. This would provide vital information for our society which is so dependent on high-tech systems in our everyday lives," says Dr. Ran Si, post-doc in this joint effort by Lund and Fudan Universities.

The method involves what could be labeled a quantum-mechanical interference. Since basically all information about the sun reaches us through "light" sent out by ions in its atmosphere, the magnetic fields must be detected by measuring their influence on these ions. But the internal magnetic fields of ions are enormous—hundreds or thousands of times stronger than the fields humans can generate even in their most advanced labs. Therefore, the weak coronal fields will leave basically no trace, unless we can rely on this very delicate effect—the interference between two "constellations" of the electrons in the ion that are close—very close—in energy.

The breakthrough for the research team was to predict and analyze this "'eedle in the haystack' in an ion (nine times ionized iron) that is very common in the corona.

The work is based on state-of-the art calculations performed in the Mathematical Physics division of Lund University and combined with experiments using a device that could be thought of as being able to produce and capture small parts of the solar corona—the Electron Beam Ion Trap, EBIT, in Professor Roger Hutton's group in Fudan University in Shanghai.

"That we managed to find a way of measuring the relatively weak magnetic fields found in the outer layer of the sun is a fantastic breakthrough," concludes Tomas Brage.

More information: Ran Si et al, A First Spectroscopic Measurement of the Magnetic-field Strength for an Active Region of the Solar Corona, *The Astrophysical Journal* (2020). DOI: 10.3847/2041-8213/aba18c

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