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A HOME-MADE ANALOGY THAT HELPS STUDY SOLAR SPICULES IN THE LAB

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Lab set-up: The paint on the speaker is being excited at definite frequency and a slow-motion camera films the jets as they form. | Photo Credit: O.V.S.N. Murthy

A team of interdisciplinary researchers from India and the U.K. led by astronomers from the Indian Institute of Astrophysics, Bengaluru, have explained the origin of ‘spicules’ on the Sun, using laboratory experiments as an analogy.

The Sun, our closest star, continues to present us with numerous puzzles. One problem concerning the Sun that our astronomers are keen to study has to do with solar spicules. These are jets of plasma, shooting out from the Sun’s outermost layer – the Chromosphere – and making incursions into its atmosphere.

Many modellers have tried, but unsuccessfully, to match the size and abundance of these features, which play important roles in at least two deep problems in solar physics. Now, in the study, published in *Nature Physics,* these researchers have found a way to study spicules in the lab using an analogous system – paint is poured on the mouth of a speaker which is fed the music that causes it to break out in spicule-like jets!

Solar spicules rise like forests from the Sun’s Chromosphere and pierce the Sun’s atmosphere or Corona. A typical spicule may be 4,000-12,000 kilometres long and 300-1,100 kilometres wide. These are structures that are believed to transport momentum to the solar wind and to provide heat to the solar Corona, which, intriguingly, can be a million degrees Celsius hotter than the Chromosphere.

The researchers found an analogous system in the most unlikely of places – a blob of paint dancing on the surface of the mouth of an audio speaker. Normally, if you place a liquid in a petri dish on the mouth of a speaker and turn up the frequency of the sound passing through it, at some frequency, the liquid’s free surface becomes unstable and starts vibrating. If the liquid is like paint or shampoo, instead of forming droplets, it will form long jets. This is because the fluid’s long polymeric chains give it a directionality.

“The spark came from our (then 8-year-old) daughter watching videos of paint dancing on a big (bass) speaker’s cone in slow-motion and commenting that they look like ‘your spicule videos’,” says Dr Piyali Chatterjee who is at the Indian Institute of Astrophysics, in an email to *The Hindu.* She conveyed this to her collaborator and husband, Dr. O.V.S.N. Murthy, who is at the School of Arts and Sciences at Azim Premji University, Bengaluru, and an animated discussion followed in which they estimated that accelerations must be several times that of respective gravity values. Dr. Murthy started experimenting on iodinated poly vinyl alcohol (also used in photographic films) and poly-ethylene alcohol. Their observations convinced them that they were on the right track with the analogy.

“Publish-worthy experiments were performed and filmed with a better camera, long-chain polyethylene oxide system, again, at home, while the disruption [due to lockdowns] continued, and we were able to set up simulations,” says Dr Chatterjee.

The researchers then did a simulation of the Sun’s surface and showed that a similar mechanism to what they used in the lab experiment can create spicules in the solar plasma. “Numerically driving a harmonic or Faraday-like excitation in plasma was something that we borrowed from the lab experiments,” says Dr. Chatterjee. The simulation showed them the strong similarity between the two systems. The simulation also matched the solar spicules quantitatively.

When asked about the fundamental questions that this method can answer, Dr. Chatterjee says the following: Trying to understand the origin and nature of solar spicules is of fundamental importance for not just Coronal heating but also mass supply to solar wind. The spicules are believed to act like channels to transport mass, momentum and energy to the Corona of the Sun.

The team from the U.K. worked on data analysis from observations taken by the IRIS spacecraft and contributed advanced processing techniques, says Dr. Chatterjee, while she and her PhD student Sahel Dey did the simulations. Dr. Murthy designed and performed the experiments.

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