

LET ME summarise the story so far. On the one hand, a full theory of the solar dynamo, one which explains and predicts the time variations of solar activity, does not yet exist. On the other, some studies over the past few decades has hinted at a possible connection between solar activity and the motions of the planets.

Again, let me stress, we have no ideas as to why the motions of the planets might affect solar activity.

But in science, what may appear as crazy ideas, departing from current wisdom, do occasionally turn out to have substance, setting foundations for new theories with even greater explanatory and predictive power.

A FIRST STEP might therefore be to see whether we can test the idea that planetary motions might affect solar activity – whether we believe it or not, and whether we have a theory for it or not.

In this spirit, Perryman et al. (2011) showed that this idea could indeed be tested in other exoplanetary systems. Systems showing large changes in the star's acceleration due its orbiting planets should also show related signatures in the activity indices of the host star, if this hypothesis is correct.

The exoplanetary systems HD 168443 and HD 74156, for example, both have periods when the changes in orbital angular momentum of their host stars exceed that of the Sun by 5 orders of magnitude. They could offer an independent test of any link between a star's barycentric motion and stellar activity. But, to my knowledge, no such tests have been made so far.

THIS STORY now takes another turn. In December 2019, I was contacted by a scientist working at CERN, Konstantin Zioutas, who drew my attention to his recent paper in the journal *Physics of the Dark Universe*, with the title ‘*The Sun and its planets as detectors for invisible matter*’ (Bertolucci et al. 2017) and was keen to hear my opinion of it.

Their work had looked at the incidence of solar flares over several decades (both what are called M flares and X flares), and found a significant relationship between this type of solar activity, and the positions of Mercury, Venus, and the Moon. And they tied this behaviour to the possible effects of dark matter.

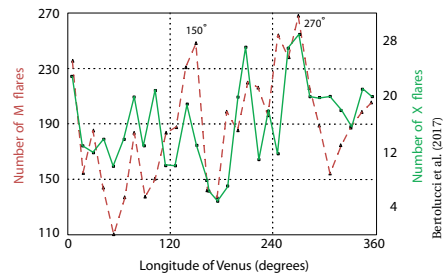
The detection and characterisation of dark matter is, of course, one of the central challenges in modern physics. The strongest evidence for it comes from large-scale gravitational effects, but more direct searches for it have so far provided no convincing evidence.

While observations, and cosmological theories, suggest that the dark matter halo in the Galaxy is distributed rather uniformly, there is also evidence for ancient stellar streams in the outer regions of our Galaxy which represent smaller galaxies captured by it billions of years ago. These captured galaxies presumably also contained entrained dark matter.

THEIR IDEA was as follows. For certain dark matter particle masses, streaming towards the Sun with velocities $10^{-4} - 10^{-3}$ times the speed of light, the particles would be gravitationally focused by a planet. If there are preferred directions in the dark matter streams, then more pronounced solar activity would be expected at certain planetary heliocentric longitudes.

Their work focused on the two inner planets, Mercury and Venus, given their relatively short orbital periods compared to a solar cycle of about 11 years. They found, since 1976, over four solar cycles, statistically significant solar activity signals when one or more planets have heliocentric longitudes between $230 - 300^\circ$.

Their hypothesis, then, is that the activity of the Sun is triggered by the influx of invisible massive matter, and that this matter has some preferred direction or stream, which gets gravitationally lensed by the planets.



UNABLE TO SEE any basic flaw in their arguments, I suggested two tests that could be made, again by appealing to other planet-hosting star systems.

The first would be to look at the stellar activity of nearby exoplanet systems, to see if it is associated with regular alignments of its planets with some preferred direction in space. And if the hypothesised dark matter stream is related to large-scale ‘infall’ structure in the Galaxy, then flare activity in those systems should be correlated with the same Galactocentric longitude.

The second appeals to an examination of Gaia data. Let us hypothesise that the various solar variability indicators are indeed revealing the presence of infalling dark matter, and that the dark matter flow correlates with the path of some ancient stellar stream. Then there could be evidence for correlated space motions of ancient low-metallicity stars following this same dark matter path.

I don't have enough understanding of both sides of the problem, dark matter physics and stellar halo streams, to decide whether the hypothesis has some obvious flaw. I sent an outline of the problem, and my suggested tests, to a number of colleagues who perhaps had the tools at hand to examine it more carefully. I await further insights into the question with interest!

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Postscript, 10 Mar 2022: a study by Edmonds (2022) argues that the inclusion of Planet 9 in the Sun's barycentric motion improves the correlation with solar activity cycles.