The search for magnetic reconnection in solar flares

In the September 2013 issue of PHYSICS TODAY (page 12), Johanna Miller describes the quest to determine how magnetic reconnection powers solar flares. Plasma structures tantalizingly suggestive of reconnection have been observed from the ground and from space since the 1960s. The new images from the Atmospheric Imaging Assembly that she cites offer higher angular resolution, but they cannot overcome a basic limitation: Studies of coronal morphology and motions can never, in themselves, demonstrate the existence of reconnection.

Rather, such studies leave solar physicists in a position reminiscent of one they faced a century ago, when the vortex-like structures observed around sunspots suggested that they were of magnetic origin. Proof, however, came only when George Ellery Hale used Zeeman splitting to actually detect the spots' intense magnetic field.

As Miller mentions, a key signature of reconnection seems to be an intense motional *electric* field.[1] Some evidence for such fields has been observed using a relatively simple polarimeter to measure the Stark effect.[2] A state-of-the-art electrograph installed on, for example, the Advanced Technology Solar Telescope or flown in space could open the door to more sensitive study of motional electric fields. Comparison of those observations with the recently developed three-dimensional flare models that Miller describes might finally enable us to decipher the role of reconnection in flares.

Only observations can settle whether the potential drops expected with reconnection occur across solar structures that produce detectable emission in Stark-affected hydrogen lines. We need to explore more incisive diagnostics complementary to extreme UV imaging if we want to understand magnetic energy release in astrophysical phenomena.

References

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2. P. Foukal, B. Behr, *Solar Phys.* **156**, 293 (1995).

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A lesson in defining "extinct"

Toni Feder's Issues and Events news item about the High-Altitude Water Cherenkov Gamma-Ray Observatory under construction in Mexico (PHYSICS TODAY, October 2013, page 22) begins by describing the site as "nestled at 4100 m on the slopes of Sierra Negra, an extinct volcano." However, as the picture accompanying her piece or a cursory examination in Google Earth makes clear, the site is not on the slopes of Sierra Negra. It sits in the saddle between Sierra Negra and its much larger companion Pico de Orizaba, also known as Citlaltépetl. Sierra Negra, a minor flank cone of that larger volcanic system, may now be extinct, but Pico de Orizaba (http://www.volcano.si.edu/volcano.cfm?vnum=1401-10=) absolutely is not. It is dormant at best, having erupted as recently as 1846.

To compound the issue, the photograph shows that the observatory site is built squarely in front of an obviously young lava flow. Now, I'm sure that site selection was done with due attention to natural hazards, but as long as astronomers insist on building expensive observatories on top of volcanoes, there needs to be clear understanding and common vocabulary between astronomers and geologists. "Extinct" is a troublesome word when applied to a volcano.

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Alternative models of the Moon's origin

The idea that our Moon originated by collision of a large space body with Earth[1] has much shakier foundations than its almost universal acceptance might suggest. Before 2012 no published giant-impact model completely supported that hypothesis. All attempts to explain isotopic identity of Apollo samples and Earth's mantle left too much alien impactor material in the resulting Moon.[2]

In 2012 a new mechanism became the basis for the first successful giant-impact models.[3] That mechanism allowed early Earth at the moment of impact to be spinning near its approximately 2.7-hour limit of rotational stability. With that added energy, the impactor could blast part of the mantle into an orbiting cloud, a future moon polluted only by acceptably small traces of the impactor. The new mechanism of lunar–solar tidal resonance transfer, a descendant of George Darwin's original lunar origin by tidal interaction,[4] then reduced angular momentum to near-modern values.

The new models have the same initial conditions as fission models of the 1960s—namely, a very rapidly spinning, partially segregated, early Earth. Elimination of excess angular momentum by the new mechanism removes once fatal objections to fission hypotheses. In these revitalized models late-stage core segregation increased the rotation rate beyond stability limits[5] to separate single or multiple parts of the mantle as lunar precursors. Subsequently a combination of tidal transfer; late-stage, backward-directed impacts; magnetic braking; drag in the solar wind; or escape of a silicate atmosphere,[5] other volatiles, small debris, or other moonlets reduced angular momentum to near-modern levels.

Distinctions between these contrasting hypotheses are already blurred. Authors of the new model note that it "blends aspects of the original impact hypothesis . . . and the fission hypothesis."[3] In reality giant impact is an unnecessary complication. Reinstated fission models could include possibilities for separation into two bodies, multiple moonlets, or equatorial fragmentation and reassembly. All avoid celestial dynamic baggage and impactor contamination while invoking the same rapid rotation and momentum-reduction