LETTERS TO PROGRESS IN PHYSICS

Commentary Relative to the Distribution of Gamma-Ray Flares on the Sun: Further Evidence for a Distinct Solar Surface

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High energy gamma-ray flares are almost always observed near the limb of the Sun and are seldom, if ever, visualized in the central region of the solar disc. As such, they exhibit a powerful anisotropy best explained by invoking a true photospheric surface. In this regard, the anisotropic nature of the gamma-ray emissions from high-energy flares constitute the eighteenth line of evidence that the Sun is condensed matter.

Every body has a surface.
St. Thomas Aquinas [1]

In the middle ages, as St. Thomas Aquinas was reflecting upon *The Infinity of God*, he was confronted with this objection relative to objects and their surfaces [1]. Thomas would answer that: "*It is one thing to be infinite in essence, and another to be infinite in magnitude*" [1]. Though nearly a millennium has passed since the Dominican Friar contemplated *The Infinity of God*, the fact remains that, in the physical world, one is primarily considering magnitude, not essence: on a macroscopic scale, every physical body does indeed have a surface. Failure to meet this criterion results in an assembly of many bodies.

These ideas have consequences for astronomy. Within the context of accepted solar models, the Sun must be viewed as an assembly of bodies, since it has long ago been deprived of a real surface by gaseous constructs [2].

Conversely, the author has argued that the Sun does indeed possess a real surface [3] and he has recently assembled a wide variety of proofs that highlight its condensed state of matter (see e.g. [4] and references therein). In this brief work, an 18th line of evidence is provided.

In 1989, Erich Rieger published a paper in *Solar Physics* entitled "*Solar Flares: High Energy Radiation and Particles*" [5]. In this report, Rieger provided strong evidence that flares with emissions >10 MeV are visible only near the solar limb (see Fig. 1). Rieger's findings would be highlighted by R. Ramaty and G. M. Simnett in their review on accelerated particles in solar flares: "*Gamma-ray emitting flares are observed from sites located predominantly near the limb of the Sun (see, e.g. Rieger 1989). This effect was observed for flares detected at energies >0.3 MeV, but it is at energies >10 MeV that the effect is particularly pronounced ... Since in both of these cases the bulk of the emission is bremsstrahlung from primary electrons, these results imply that the radiating electrons are anisotropic*" [6, p. 237]. It was then postulated that: "*... the anisotropy could result from the mirroring of the charged particles in the convergent chromospheric magnetic fields*" [6, p. 237] based on a theoretical analysis by Miller and Ramaty [7]. These authors comment that the emissions are "*... strongly anisotropic, with more emission in the directions tangential to the photosphere than in directions away from the Sun*" [7]. In order to account for the anisotropy of the gamma-ray emission from high energy solar flares, they invoke electron transport in the coronal region and magnetic mirroring of converging magnetic flux tubes beneath the transition region [7]. As the gaseous models of the Sun cannot support the existence of a real surface, then another mechanism must be created to "act as a surface".

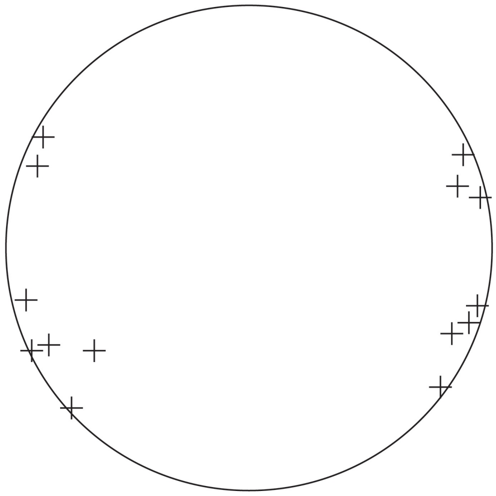

Fig. 1: Schematic representation of the relative position of flares with >10 MeV of energy on the solar disk displaying their predominance near the limb. This figure is meant only for illustrative purposes and is an adaptation based on Fig. 9 in [5] which should be examined for exact flare locations.

Within the gaseous models, the photosphere merely represents a region of increasing opacity, best regarded as an "optical illusion" [3]. The gaseous Sun possesses no sudden change in density which could allow tangential emission to its surface. In fact, modern solar models assume a density of only 10^{-7} g/cm^3 for the photosphere [8, p. 32], a density lower than some of our earthly vacuums. Hence the use of magnetic mirroring and the convergence of field lines in order to generate surface effects in the absence of condensed matter.

In the end, the simplest way to account for the strongly anisotropic nature of high energy solar flares is to recognize the existence of a discrete surface on the Sun. This most elegantly explains why the emissions are *tangential to the photosphere*. As flares rise from the solar interior [4] they eventually arrive at the photospheric layer. High energy gamma rays are emitted tangentially to this boundary, as a real physical surface, not to an illusion [3], has been encountered.

Acknowledgment

Luc Robitaille is recognized for the preparation of Figure 1.

Dedication

Dedicated to Dominican Friars of the Province of St. Joseph.

Submitted on: January 17, 2013 / Accepted on: January 18, 2013
First published in online on: January 28, 2013

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