Contribution ID: **242** Type: **Poster**

Electron thermal escape in the Sun

Wednesday, 8 September 2021 09:26 (13 minutes)

Magnetic field vector observations in the solar photosphere have generally revealed a non-zero value of the divergence: the vertical field component gradient is found on the order of 3 G/km when the horizontal field component gradient is of 0.3 G/km only. This has first to be assigned to the fact that the measured quantity is the magnetic field H, which is related to the divergence-free magnetic induction B by the law B=μ0(H+M), where M is the magnetization. In plasmas like the solar photosphere, magnetization results from plasma diamagnetism and spiral movement of charged particles about the magnetic field. It can be observed that in the solar interior the electron thermal velocity is much larger than the escape velocity from both gravity and proton attraction. A model of this is presented in the related paper (Bommier, V., "Solar photosphere magnetization", 2020, A&A, 634, A40). The electrons escape from lower layers in a quasi-static spreading, and accumulate in the photosphere. Therefore, the electron density at surface is increased but decreases with height at surface, which enables the observed values because divH = -divM. Such a structure is probably at play in the solar-type stars. Besides, solar magnetohydrodynamics must include the fact that the quantity measured by Zeeman effect is H (4 demonstrations in the paper), which is related to the electric current j by the Maxwell relation rotH = j, where j is itself submitted to the Lorentz force j x B, where B is the divergence-free magnetic induction.

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Session Classification: Poster Session 5.1

Track Classification: Session 1 - Solar Interior, Dynamo, Large-Scale Flows and the Solar Cycle