ELECTRON THERMAL ESCAPE INSIDE THE SUN

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The magnetic field vector observations in the solar photosphere systematically display a non-zero value of the divergence whatever the observation spatial resolution is. The vertical gradient is found on the order of 3 G km^{-1} when the horizontal gradient is found on the order of 0.3 G km^{-1} only. The difference is much larger than the measurement uncertainties. It must then be recalled that the quantity measured by interpretation of the Zeeman effect is the magnetic field $\vec{H}$. Four demonstrations can be found in Bommier (2020), also available at `https://doi.org/10.1051/0004-6361/201935244`. The magnetic field $\vec{H}$ is related to the divergence-free magnetic *induction* $\vec{B}$ by the law $\vec{B} = \mu_0(\vec{H} + \vec{M})$, where $\vec{M}$ is the magnetization. In plasmas like solar photosphere, magnetization results from plasma diamagnetism, which is due to spiral movement of charged particles about the magnetic field. However, the usually admitted value of the electron and charge density, although not directly determined, leads to very weak magnetization. It has to be remarked that in the solar interior the electron thermal velocity is 14 times larger than their escape velocity, and also 6 times larger than their escape velocity from protons. However, when the electron density decreases by escape, the proton keeping effect increases. The electron escape is however very slow and results in accumulation in surface layers. The order of magnitude of the observed magnetic field gradient is recovered from the height estimated decrease of the electron density and from $\mathrm{div}\vec{H} = -\mathrm{div}\vec{M}$. This model is presented in Bommier (2020). Such a structure is probably at play in solar type stars, with electric fields because protons do not escape. The solar and stellar MHD has to adapt to the fact that what is measured is $\vec{H}$ and not $\vec{B}$, which has to be related to the second Maxwell equation $\mathrm{curl}\vec{H} = \vec{j}$.

References

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