Alfven's View of How Space Plasmas Interact

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Alfven was troubled by the indiscriminate use of the ideal MHD relation **E**+**V**x**B**=0 in studying collisionless space plasmas. This equation comes from the Lorentz transformation equation **E**'=**E**+**V**x**B** that assume plasmas have infinite conductivity. We can test the capability of **E**+**V**x**B**=0 physics by observing how a solar wind interacts with electromagnetic fields of magnetized planets. Chapman and Ferraro (1931) showed that a solar wind that is approaching a planet forms a boundary by inducing a current (dφ/dt=-EMF). But **E**+**V**x**B**=0 conserves the total magnetic flux dφ/dt =0, which means ideal plasmas cannot induce currents and form boundaries. Relativity theory sheds further light on this problem. An observer in the planetary frame sees currents are formed by the magnetic force that moves ions and electrons in opposite directions. However, the observer in the solar wind frame sees no magnetic force, but concludes that the electric force must be responsible. The theory of relativity shows the charge density (ρ) responsible for **E**' is due to Lorentz contraction of the current source in the moving planet as seen in the solar wind frame. **E**' while small in good conductors must be retained if the physics is to be consistent with the relativity principle. Our results endorse Alfven's paradigm that space plasma interactions are correctly described through currents and electric fields.