Stellar CME activity and its possible influence on exoplanets' environments

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Abstract

CMEs are large-scale magnetized plasma structures carrying billions of tons of material that erupt from a star and propagate in the stellar heliosphere, interacting in multiple ways with the stellar wind. As one of the most important factors of the stellar activity, they are believed to be a critical element in the stellar dynamo which removes the dynamo-generated magnetic flux from the star and connects the internal stellar dynamo processes to the external stellar environment. Due to the high speed, intrinsic magnetic field and the increased plasma density compared to the stellar wind background, CMEs can produce strong effects on planetary environments when they collide with a planet. The main planetary impact factors of CMEs, are associated interplanetary shocks, energetic particles accelerated in the shock regions, and the magnetic field disturbances which create magnetic storms. All these factors should be considered during the study of the CMEs' role in creation of particular planetary conditions. Important parameters for characterization of the 'stellar CMEs - planetary atmosphere and surface interaction' are the density and velocity of the CMEs plasma. These may be highly variable with stellar age, as well as dependent on the stellar spectral type and the orbital distance of a planet. Because of relatively short range of propagation of majority of CMEs, they impact most strongly the magnetospheres and atmospheres of close orbit ($<$ 0.1 AU) planets.
We have currently a good knowledge of CME parameters on the Sun, whereas the amount of corresponding data related to other stars is much more limited. On the Sun, CMEs are associated with flares and prominence eruptions and their sources are usually located in active regions and prominence sites. The likelihood of CME-events increases with the size and power of the related flare event. Therefore, the existing correlation between strong flares and CMEs on the Sun is often used, assuming a solar-stellar analogy, for judging about CME activity on active flaring stars. It is expected that the frequent and powerful flares on magnetically active flaring stars should be accompanied by an increased rate of CME production.

The plasma of stellar CMEs colliding with a planet, interacts with the planetary magnetosphere, and in the case of a weak magnetospheric protection (i.e., weak or no intrinsic

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planetary magnetic dipole), the magnetosphere is compressed down to the planetary surface, resulting in strong erosion of the planetary atmosphere. Sufficiently large magnetospheres are known to protect the underlying planetary environments, e.g. ionosphere, atmosphere, and surface against of stellar XUV/EUV and stellar wind factors. These usually require strong enough intrinsic planetary magnetic fields and/or extended magnetospheric current systems such as magnetodisks.
In the present talk we discuss the role of such factors like activity of a host star and intrinsic magnetic field of a planet and show how the account of these factors may influence the erosion of planetary upper atmospheres and their mass loss throughout the lifetime of a planet.

Keywords: stellar activity, stellar CMEs, exoplanets, magnetospheric protection