

Lightning on exoplanets and brown dwarfs: modelling lightning energies and radio powers

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Lightning is a well studied though not fully understood phenomenon occurring not just on Earth but on other Solar System planets, such as Jupiter and Saturn, as well. Both observations and theoretical work suggest that the conditions in extrasolar planetary and brown dwarf atmospheres are good for lightning to occur. However, due to the lack of exo-lightning observations, we do not know how lightning in extrasolar atmospheres is similar or different from what is known from the Solar System.

The aim of this study is to apply our knowledge of lightning production, derived mostly from Earth lightning, to the potential lightning discharge characteristics on extrasolar objects. In terms of observations, the power spectrum of lightning carries information regarding radiated power densities. From the total radiated power it is also possible to determine the energy dissipated from lightning discharges. However, modelling the power spectrum involves several steps and various parameters, including a characterization of the electric field. As such, we built a model and conducted a parameter study in order to explore the possible lightning powers and energies in different types of extrasolar atmospheres, such as giant planetary and brown dwarf atmospheres.

We tested our model on Solar System cases based on previously published parameters in the literature, such as the duration of the discharge or the frequency at which the peak power is released. Our tests reproduce these published values for Earth, Jupiter and Saturn, and validate our model. When applying the model to extrasolar lightning discharges, we found that in giant gas planet atmospheres of $1500 \text{ K} < T_{\text{eff}} < 2000 \text{ K}$ and $\log(g) = 3.0$ the dissipation energy of lightning can reach as high as 10^{19} J , which is ten orders of magnitude larger than the average total energy of Earth lightning.