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Radio signatures of lightning discharges in exoplanets and brown dwarfs

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Lightning related signatures can be found in the whole spectral range from radio to gamma-rays. While for example UV, visible or IR molecular emission (as the lightning discharge causes changes in the local chemistry) depends on the composition of the atmosphere of the extrasolar body, radio signatures do not have this limitation, which means they may give us a universal tool for lightning observations outside the Solar System, both on exoplanets and brown dwarfs.

Lightning induced radio signatures have three main types. Sferics emit in the low-frequency (LF) range with a power density peak at 10 kHz on Earth. (Aplin, K. L., 'Electrifying atmospheres', Springer 2013) Whistlers are electromagnetic waves propagating along magnetic field lines and emitting in the very low-frequency (VLF) range. (Desch, S. J. et al. 2002, Rep. Prog. Phys. 65, 955) While Schumann-resonances are VLF lightning discharge-induced electromagnetic oscillations of the earth-ionosphere cavity. (Simões, F. et al. 2012, LPICo 1683, 1052)

There are certain factors that limit the observability of radio signatures. Every object with an ionosphere has a low cutoff frequency. This means radio waves with frequencies below this peak-frequency cannot propagate through the atmosphere. For Earth this value is about 5-10 MHz. However, the values for extrasolar atmospheres remain to be determined. Besides that, natural background noises like the galactic radio background or photo-electron noises give a limitation. (Zarka et al. 2012, PSS 74, 156)

Putting all together, radio signatures with frequency below 10 MHz might only be observable from space. Waves below 30 kHz would not be able to reach the inner Solar System. (Zarka et al. 2012, PSS 74, 156)

We show a general summary of radio signatures and their properties. A table of other lightning discharge signatures that have been observed either on Earth or other Solar System planets is also included. This table, also contains a list of different instruments (spectrographs and telescopes) that would be able to detect lightning signatures coming from distant objects based on their operating wavelength range. (R. L. Bailey, Ch. Helling, G. Hodosán, C. Bilger, C. R. Stark 2013, ApJ, accepted)