URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Does Anion Oxidation Drive Meteor Radio Afterglows?

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We present a theoretical framework and evidence to explain the energy source for meteor radio afterglows (MRAs), where exothermic chemical reactions between negatively charged (anion) metal clusters and atmospheric oxygen drive radio emission. MRAs, which occur in the plasma trails of some bright meteors, were discovered in 2014 using the first station of the Long Wavelength Array (LWA1) [1]. They are characterized by a long duration (few seconds to a few minutes) broadband (20-60 MHz) radio pulse with little to no polarization. Usually MRAs are observed by the LWA radio telescopes to be point sources, but occasionally multiple locations along the plasma trail can display MRA emission. While the emission mechanism responsible for MRAs is currently unknown, any mechanism would require a source of suprathermal electrons that is generated continuously for at least a few minutes.

Metals deposited in meteor trails have long been thought to react with atmospheric oxygen and produce long lasting optical glow known individually as a persistent train (PT). Observable after the ablation of some bright meteors, PTs are characterized by long duration (minutes to hours) visible and near infrared emission coming from all or parts of the trail [2]. The PTs are deformed by the neutral wind shear in this altitude range. As a result, the trains can evolve into twisted and contorted shapes with time.

Using the Widefield Persistent Train camera (WiPT) and the two LWA stations in New Mexico, we find a connection between MRAs and PTs, where the two phenomena are both spatially and temporally correlated. Furthermore, we show that chemical reactions between negatively charged metallic ions (anions) and oxygen, could produce the necessary population of suprathermal electrons. In this scenario, metal clusters rapidly attach free electrons in the turbulent meteor plasma, and when these anion clusters oxidize the electrons are kicked off with energies in the range of a few eV. For a typical MRA producing meteor, these hot electrons provide enough energy such that only one part in 10^{10} needs to be converted into radio emission to match the observations [3].

References

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