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Do meteors radiate very-low-frequency radio emissions?

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Meteors are commonly observed through their optical emissions, but also through scattering of radar waves transmitted from the ground, typically in high frequency (HF, 3–30 MHz) through ultra-high-frequency (UHF, 0.3–3 GHz) bands. Recently, it has been demonstrated that meteors in fact radiate HF/VHF emissions naturally [1]. These emissions raise questions into the physical mechanism that produces this radiation, as well as provide insight into the development and evolution of meteor plasma.

Dating back to the late 1950s, it has been investigated that meteors may radiate in the very-low-frequency band (3-30 kHz). It was first theorized meteors were related to audio signatures through electrophonics in a nearby conductor [2]. Recent work has presented direct measurements of VLF signals associated with meteors [3,4]. Such VLF emissions from meteors would raise valuable questions about the mechanism of emission from the meteor plasma. However, there exists no consensus as to whether the observed VLF signature scan be causally connected to the observed meteors. Using a modern VLF receiver and a sophisticated network of meteor cameras, Sung et al. [5] studied two years of meteors and their associated VLF emissions, but found no evidence of a unique meteor-associated VLF signal.

In this paper, we present the development and first results from a new VLF and meteor camera network in pursuit of these elusive emissions. Four all-sky meteor cameras have been installed in Colorado and Utah since the summer of 2020, along with three VLF receivers. One more camera is planned to be deployed in early 2022. The cameras utilize the University of Western Ontario's automated meteor detection software to extract meteor events from sunset to sunrise every night. Broadband, 0.3–50 kHz VLF data is recorded continuously at all sites and then post-processed using time signatures to extract segments of data during meteor observations. Since July 2020, hundreds of meteor observations have been collected and analyzed.

To search for VLF signatures of meteors, we apply a variety of signal processing techniques to the data in order to separate other natural and anthropogenic signals from potential meteor signatures. Of particular interest, we apply a "Sparse Separation" technique [6] to extract Fourier components (e.g. powerline harmonics and VLF transmitter signals) and Wavelet components (e.g. lightning-generated sferics). The remaining signal, extended in both time and frequency and hence "noise-like", provides an avenue to search for unique signatures. We compare each of these data components, alongside Vaisala lightning data, before, during, and after meteor observation times to identify enhancements in the temporal or spectral signatures. Despite this thorough analysis, to date no clear evidence of VLF emissions associated with our meteor observations has been found. Nonetheless, we will continue to collect and analyze data with the goal of providing the most concrete evidence, to date, either for or against VLF emissions from meteors.

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