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The Early ULF Signal of the Gigantic Jets Revealed By Hilbert-Huang Transform

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The conventional Fourier analysis on the sferics in ULF and VLF bandpasses has been done for years. Several phenomena e.g. whistler and Schumann resonance have been well studied by the Fourier spectrum comprehensively. But the Fourier analysis is computed by an integration over time, therefore, the temporal resolution is smoothed, and limited not only by the sampling rate but also the size of the integration window. The instantaneous frequency can't be obtained through this conventional approach. We introduce the Hilbert-Huang transform (HHT) instead of Fourier transform to analyze the sferics of TLEs recorded at Lulin observatory. The Hilbert–Huang transform decomposes a signal into so-called intrinsic mode functions (IMF), and derive instantaneous frequency data by differentiating the phase angle yielded by Hilbert transform. Our analysis of HHT on several gigantic jets recorded by ground observation surprisingly revealed an early signal of frequency-change during the phase of the leading jet, and this early signal can not be identified by Fourier analysis. In the phase of leading jet, the amplitude of the sferics remains a constant and no significant features are recognized in the recorded waveform, but an obvious frequency change about 100-200 millisecond prior to the main discharge of the full development jets (FDJs), which can be clearly recognized in the HHT spectra of all observed gigantic jets. From a further simulation, this frequency change is confirmed to come from the nature of the discharge, not an alias or a false signal generated by the analysis method. This early signal may implies an in-cloud discharge process which is suggested by Krehbiel et al. [2008]