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Rapid motions of source regions of whistler-mode chorus waves and implications for triggered VLF emissions

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Recent observations of ELF/VLF discrete chorus emissions on multiple CLUSTER spacecraft has provided the first opportunity to directly measure the spatial extent and the rapid motion of the source regions of these intense emissions. With simultaneous observations of the same individual discrete emissions on up to four spacecraft, at distinctly different apparent frequencies, it has been possible to pinpoint the source regions with high precision, and to uncover the remarkably rapid (up to 0.01 to 0.05 of the speed of light in free space). These new observations raise interesting questions concerning the generation mechanisms of chorus waves, since previous theoretical or simulation models have not accounted for such rapid motion. This new realization also suggests that the source regions of VLF triggered emissions may also exhibit such rapid motion. VLF triggered emissions are a remarkably nonlinear phenomena which has been investigated in some detail in controlled VLF wave-injection experiments with the Siple Station, Antarctica transmitter. Triggered emissions are in many ways quite similar to spontaneously emitted discrete chorus elements, consisting of rising, falling or hook-shaped coherent tones, triggered by a relatively weak coherent input signal in an otherwise quiet magnetoplasma, following rapid temporal growth. Triggered emissions exhibit many spectacular examples of nonlinear phenomena, including threshold growth, saturation, entrainment, coherent suppression, strong dependence on frequency-time shape. In this talk, we review the recent CLUSTER observations of discrete chorus emissions and the rapid motions of their sorce regions, and discuss implications in terms of the generation mechanisms of both chorus and triggered VLF emissions.