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Controlling the Chirping of Chorus Waves via Magnetic Field Inhomogeneity

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Whistler mode chorus is a type of naturally occurring electromagnetic emission in planetary magnetospheres. This important wave is known to produce relativistic electrons in the hazardous radiation belts and to precipitate energetic electrons from space into the upper atmosphere to form diffuse aurora. Chorus consists of discrete spectral elements with fast frequency chirping in either upward (rising-tone) or downward (falling-tone) directions. A long-standing problem is to understand the origin of different chirping directions and their distinctive observational properties. Here, we show, by first-principle particle simulations, that the background magnetic field inhomogeneity plays a key role in determining the chirping direction and that the dipole geometry of Earth's magnetic field essentially controls the properties of chorus. Our results naturally account for the dominance of rising-tone chorus and the oblique propagation of falling-tone chorus and provide important insights into the fundamental mechanism of the nonlinear chirping process. The propagation properties of chorus are also expected to be similar in all planetary magnetospheres with a dipole-type magnetic field.