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Electron acceleration by intense whistler-mode waves at foreshock transients

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The shock wave is a primary interface for plasma heating and charged particle acceleration. In collisionless solar wind plasma, such acceleration is attributed to the wave-particle resonant interactions. This letter focuses on electron acceleration by one of the most widespread high-frequency electromagnetic wave emissions, whistler-mode waves. Using spacecraft observations of the Earth's foreshock transient, we demonstrate that intense whistler-mode waves may resonate nonlinearly with $\sim 10-100$eV solar wind electrons and accelerate them to $\sim 100-500$eV. Accelerated electron population has a butterfly pitch-angle distribution, in agreement with theoretical predictions. The presented evidence of the efficiency of nonlinear resonant acceleration suggests that this mechanism may play an important role in solar wind electron injection into the shock-drift acceleration.