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Lattice dynamics, crystal-field excitations and quadrupolar fluctuations of $YbRu_2Ge_2$

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We report Raman scattering results of $YbRu_2Ge_2$ single crystals to explore the phononic and crystal-field (CF) excitations. This heavy-fermion metal enters a B_{1g}-symmetry ferroquadrupolar (FQ) phase below T_Q=10K. We establish the CF level scheme of the ground multiplet. We demonstrate that the static Raman susceptibilities in both B_{1g} and B_{2g} quadrupole channels exhibit a Curie-Weiss behavior with the Weiss temperature about 10K lower than T_Q. Electron-lattice coupling is crucial for the FQ transition to happen. Moreover, temperature-dependent study of four Raman-active phonon modes shows that the intensities of the A_{1g} and one E_g modes increase significantly on cooling, which is explained by a near-resonant coupling between these two phonon modes and CF transitions.

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