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Emerald: collective dynamics of water molecules in nano-channels

Besides jewelry aspects, the family of emeralds/beryls (ideal formula $Be_3Al_2Si_6O_{18}$) attracts interest of physicists due to their crystallographic structure composed of Si_6O_{18} hexagonal rings that form one-dimensional (along the c-axis) channels, of a nano-sized diameter and reaching 100 micrometers length. Various molecules, like H_2O, can be trapped into the channels and compose one-dimensional chains thus providing a “laboratory” for one-dimensional physics. We have measured the dielectric spectra of $Mn:Be_3Al_2Si_6O_{18}$ single crystal (pink beryl) at frequencies 7 cm^{-1} to 5,000 cm^{-1}, for temperatures between 20 K and 300 K. In the far-infrared range a series of phonon resonances is recorded. At sub-phonon frequencies, in the submillimeter region, we discover a strong absorption band centered around 20 cm^{-1}, appearing at liquid helium temperatures. We discuss the origin of the band, which can be connected with collective dynamics of water molecules that at low temperatures hop between potential minima they experience in the hexagonal channels.

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