Maser Generation of Hypersound From Heat Through Adiabatic Demagnetization of a Paramagnetic Crystal

MICHAEL VAISFEL'D, Kingsborough College of CUNY — It has been shown in our earlier work on thermal masers [Sov. Phys. - JETP (USA), v. 57, No. 6, pg. 1263-9 (1983)] that the energy of thermal phonons of a crystal like La$_2$Mg$_3$(NO$_3$)$_{12}$24H$_2$O (LaMN) doped with $^{59}$Co$^{2+}$ (ions A) and Ce$^{3+}$ (ions B) can be converted directly into the energy of coherent microwave radiation. Maser action has been observed at liquid helium temperatures in the 0.18-T static magnetic field after termination of the 1-T magnetic field pulse (which is applied for the adiabatic cooling of the electron spins $^{1/2}$ of the ions B). A partial population inversion is achieved in the system of hyperfine magnetic spin sublevels of the ions A as a result of the fast resonant thermal mixing between the nuclear spins I = 7/2 of the ions A and the cooled spins B. Our device acts as a quantum heat engine, without any microwave or optical pumping. Here we propose an analogous easily tunable pulsed phonon maser. The laser crystals of KY(WO$_4$)$_2$ [Eur. Phys. J. B55, 388-395 (2007)] doped with $^{168}$Er$^{3+}$ and $^{171}$Yb$^{3+}$ (I = 1/2) or $^{173}$Yb$^{3+}$ (I = 5/2) ions are proposed as working substances (instead of the crystal hydrate of LaMN:Ce$^{3+}$: $^{59}$Co$^{2+}$).

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