## 6.2 Low-Temperature Tunneling Dynamics of D-RADP-42 and RADP-50

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The dynamics of the proton glass phase has been studied via the $^{87}$Rb NMR spin-lattice relaxation from room temperature down to 1.6 K in RADP-50 and deuterated D-RADP-42. They reveal that while at high temperatures the dynamics is determined by thermally activated hopping of protons over the H-bond potential barrier, at low temperatures it is determined by phonon-assisted tunneling through the barrier. At low temperatures the proton glass phase is thus not frozen out and static (as characteristic for classical glasses) but shows the tunneling dynamics of quantum glasses.

Below 55 K thermally activated hopping no longer properly describes the relaxation rates. On the low-temperature side of the $T_1$ minimum the classical hopping model yields a straight line in the log($T_1$) vs. inverse temperature plot, whereas the experimental points deviate increasingly from this line and become only weakly temperature dependent below 16 K. This faster relaxation could be unambiguously assigned to phonon assisted tunneling. The phonons couple via the piezo-electric effect to the local electric polarization and thus to the hydrogen motion on the bonds. Great care had to be taken in ruling out other possible relaxation effects, as e.g. spin diffusion to paramagnetic centers. By measuring the $^{85}$Rb relaxation we could, however, prove that the relaxation is of entirely quadrupolar nature and is thus associated to the proton or deuteron dynamics, respectively.

The reason why tunneling can be observed in proton glasses, but was never observed in long-range ordered KDP systems comes from the fact, that the proton glass phase still exhibits the average symmetry of the high temperature paraelectric phase with many fairly symmetric bonds, whereas the bonds in the long-range ordered phases are so strongly biased that they probably exhibit only one potential minimum.