Quantum Zeno effect in field-free methanol gas

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The quantum Zeno effect has been observed for the ultra-cold $^{9}Be^{+}$ ions in a magnetic field[1] and at room temperature for $^{13}CH_3F$ gas in an external electric field[2]. Now we demonstrate the observation of the quantum Zeno effect at room temperature in field-free methanol (CH_3OH) gas.

The CH_3OH molecule has the torsion of the CH_3 group and of the OH group with respect to each other[3]. The molecules of CH_3OH gas are mixed by different species of nuclear-spin isomers (NSIs) whose nuclear spins of identical nuclei in the CH_3 group are entangled with each other. It is from the three spin–1/2 hydrogen nuclei of this CH_3 group that the ortho-CH_3OH and para-CH_3OH are modified, which has a total nuclear spin quantum number I = 3/2 and 1/2, respectively. We show in this study that the ortho-para conversion of CH_3OH isomers can be induced by non-magnetic molecular collisions in a quantum relaxation process from a non-equilibrium concentration of them prepared by a technique of Light-induced drift[4] towards the zero equilibrium level of their populations. The ortho-para conversion rates have been obtained by using a least-square method to fit an exponential function to the observed curves of the population variations of the ortho and para isomers at low pressures from 0.3 to 2 Torr. The pressure dependence of the obtained conversion rates clearly show the inhibition of the interconversion between the ortho-CH_3OH and para-CH_3OH isomers by frequent collisions of the re-population molecules with increasing pressures. We attribute this interesting quantum phenomenon to the NSIs-torsion-specific states-mixing systems of CH_3OH. The torsion mediates the intermodes couplings for the strongly mixing near-degenerate ortho–para level pairs and providing doorway channels for population and intramolecular energy re-distribution[5]. Usually the energy gaps between two states of molecular ions and molecules can be narrowed via splitting of the levels by the applied external electric and/or magnetic field. Here, the observation of the quantum Zeno effect at room temperature is the first time for a field-free gas induced by non-magnetic molecular collisions.

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