Macroscopic Multistate Quantum Processors Based on Stored High-Energy Polarized Beams

Dennis Sivers
Portland Physics Inst.
University of Michigan

Both the purity and lifetime of polarized beams stored in high-energy rings have improved dramatically in recent decades as progress in polarized sources and refinements in accelerator design have been implemented. In a series of experiments based at the IUCF facility located at the University of Indiana, a group led by Alan Krisch has systematically studied the spin manipulation of stored beams using a Siberian Snake as well as various induced-resonance techniques. Among other results, these experiments demonstrate conclusively that coherent spin rotation using the Froissart- Stora technique of resonance crossing can by reliably controlled with existing radio-frequency magnet technology.

It can be shown that the coherent spin rotation of stored particle beams produces <u>macroscopic</u> states with familiar quantum properties. Based on the results from the Krisch group, we conclude that the coherent spin rotation of <u>multiple</u> particle beams simultaneously controlled by RF magnetic fields can produce effective multi-state quantum processors. The resulting macroscopic particle beam systems display constructive quantum properties that can be quantitatively measured. Examples of such systems can be formed from stored beams of polarized electrons, protons or heavy ions. Because massive quantum systems with spin equal to or greater than one display some instructive interference effects not found with spin one-half states, we illustrate the basic concept with an example using stored beams of polarized deuterons.