Unexpected Enhancements and Reductions of RF Resonance Strengths*

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We recently analyzed all available data on spin-flipping stored beams of protons, deuterons and electrons. We first obtained the ratio $\varepsilon_{FS}/\varepsilon_{Bdl}$ of the rf-induced spin resonance strength ε_{FS} obtained by fitting the measured polarizations to the modified Froissart-Stora equation to the ε_{Bdl} calculated using the $\int Bdl$ of the rf dipole or rf solenoid. We found that $\varepsilon_{FS}/\varepsilon_{Bdl}$ was as much as 15 times lower than predicted for deuterons and was often 10 to 80 times higher than predicted for protons.

We studied this discrepancy with a 2.1 GeV/c vertically polarized proton beam[1] and a 1.85 GeV/c vertically polarized deuteron beam stored in the COSY cooler synchrotron in Jülich, Germany. To flip the beam's polarization direction, we swept the frequency of a water-cooled ferrite rf dipole, with $\int Bdl$ = 0.5 T·mm rms, through an rf-induced spin resonance.

We studied the dependence of $\varepsilon_{FS}/\varepsilon_{Bdl}$ on the beam size, the momentum spread and the distance from the nearest 1st-order intrinsic spin resonance for both protons and deuterons, and on the frequency sweep range Δf for deuterons. We observed no measurable dependence of $\varepsilon_{FS}/\varepsilon_{Bdl}$ on the beam size and momentum spread for both protons and deuterons. When we varied the vertical betatron tune ν_y near a 1st-order intrinsic spin resonance for both protons and deuterons, we observed a strong enhancement of $\varepsilon_{FS}/\varepsilon_{Bdl}$ with a hyperbolic dependence on the distance from the 1st-order intrinsic spin resonance; this explained much of the discrepancy for protons, but not the very small $\varepsilon_{FS}/\varepsilon_{Bdl}$ for deuterons.

We initially had deuteron data only with very small Δf values of 100-200 Hz; when we increased Δf in four steps from 100 to 3000 Hz, we observed no dependence of $\varepsilon_{FS}/\varepsilon_{Bdl}$ on Δf. Thus, this anomalously small $\varepsilon_{FS}/\varepsilon_{Bdl}$ ratio may be due to some unexpected behavior of relativistic spin-1 deuterons in an rf dipole.

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