Polarized Beam as the Pump in a Parametric Amplifier

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Abstract. Proposals to construct an rf Resonance Polarimeter may be divided into two groups, based upon whether the polarization orientation is transverse or longitudinal. They differ in the appropriate cavity modes, and in the relativistic transformation properties of the magnetic moment. Transverse orientation requires TM modes, which couple strongly to the beam charge and aggravate the problem of the beam charge background. The transverse moment has no relativistic gamma dependence. Longitudinal orientation permits using TE modes, which couple weakly to the beam charge and greatly ease the background problem. The longitudinal moment transforms as gamma. From this one might conclude that longitudinal orientation is the best choice for the rf Polarimeter. However, when one examines in detail the interaction of the polarization with the rf fields in the cavity, it becomes clear that the gradient force with which we are all familiar is, in the relativistic limit, cancelled by a force due to the effect of the time-dependence of the field. While the amount of spin-dependent energy which is being alternatively deposited and withdrawn from the cavity by the longitudinal moment appears to go as gamma, the net energy deposited in the cavity goes as 1/gamma. We propose to introduce a nonlinear element to the cavity, and suggest that interaction of this element with the alternating gamma-dependent energy in the cavity constitutes a parametric amplifier, one which preserves and enhances the advantages of employing the longitudinal orientation.

Paper not available for publication.