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Towards a High-Accuracy RF Wien Filter for Spin Manipulation at COSY Jülich

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The Jedi collaboration is aiming for electric dipole moment (EDM) measurements of deuterons and protons at COSY-Jülich. A high accuracy RF Wien filter, operating at the spin harmonic frequencies is planned to be integrated in the COSY ring at the Forschungszentrum Jülich. This RF Wien filter is intended for spin tune modulation purposes allowing to perform EDM measurements. Because of the smallness of the EDM signal, critical requirements on this Wien filter have been imposed both in terms of field homogeneity and orthogonality. The transverse electromagnetic (TEM) mode of a parallel plates'waveguide fulfills the requirements. This work will show both the electrodynamics analysis together with the engineering design.

The transverse electromagnetic mode (TEM mode) is one solution of Maxwell's equations in the parallel plates' waveguide. Two important properties of the TEM mode were used to fulfill the Wien filter condition namely the field orthogonality and the variable field quotient (ratio between the E- and H-fields). The field orthogonality was inherently gained by the transverse nature of the TEM mode. Variable field quotient was implemented using the wave mismatch theory.

The second part of this work shows the practical implementation of this idea. A full model of the system, based on the parallel plates'waveguide concept has been designed and simulated using a full-wave simulator (CST Microwave Studio). Operating at a frequency around 1 MHz (-1 spin harmonic), the results show that the achieved homogeneity values of the electric and magnetic fields are in the order of 10^{-5}, and 10^{-6} respectively along the beam axis. The calculated Lorentz force along the central beam axis is 1.5×10^{-3} eV/m.

Additional thermal simulations have been carried out in order to assess the sensitivity and stability of the system. The thermal simulations results (with 1 kW (rms) as input power), showed a maximum temperature elevation of about 6K. This increase in temperature had negligible influence on the field quality.

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