Analysis of diffraction from helicoidal baffles in gravitational wave interferometers

G. Pelosi[1], I.M. Pinto[2], L. Possenti*[1], and S. Selleri[2]

[1] DINFO, University of Florence, Florence, Italy I-50139

[2] DING, University of Sannio, Benevento, Italy I-82100

Gravitational waves detectors are designed to detect a resulting arm length change of 10^{-18} m of the two perpendicular detectors arm cavity. Hence, it has to be highly sensitive to very small changes in phase of the stored standing wave and any spurious effect is a source of noise degradating performances.

Among the noise sources there is scattered light noise, arising from those scattered rays that interact with the interferometer walls with unpredictable phase changes due to wall vibrations, either seismic, thermal or acoustic. If scattered rays recombine with the main interferometer rays interference occurs.

Baffles are hence introduced to suppress scattered rays, intercepting stray light that could reach the walls and re-couple to the main beam. Baffles are yet connected to noisy walls and can be themselves source of stray rays due to diffraction.

Techniques such as GTD and UTD give a description of the diffracted field in terms of rays emanating from diffraction points, calculated using ray-tracing based on Fermat principle, located on the scatterers and has recently been applied (G. Pelosi, et al. *ACES Journal*, 32(7), 569-574 2017) to this problem, but their applicability is severely limited by the very large dimensions of the structure with respect to the wavelength, and from the presence of diffracted ray caustics for some baffle geometries.

Conversely, physical theories, relying on equivalent currents integration, does not present these problems. Due to the nature of the baffle diffraction problem the most critical issue is that of diffracted rays from the baffle propagating along the main beam axis and capable of interfering with mirrors. Being baffle aperture very large and the laser beam highly focused the physical optics (PO) cotribution from the baffle surface tends to the GO solution, leaving only the fringe currents as main contribution. Incremental length diffraction coefficients (ILDC) allows the efficient evaluation of the physical teory of diffraction (PTD) fringe currents integrals as a single point contribution (G. Pelosi et al. *IEEE Trans. Antennas Prop.*, 40(10), 1201-1210, 1992)

A high-frequency electromagnetic analysis in terms of ILDC will hence be here applied to planar, conical and helicoidal baffles, using a Gaussian beam model for the primary field with a linearly-polarized electric field. Helical baffles prove superior since light reflection is minimized and, moreover, edge diffraction contribution does not sum up along the pipe axis, as in the planar or conical case. Numerical results will be shown at the conference.