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RESONATOR CAVITY DESIGN FOR TWO-STAGE FEL EXPERIMENT

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Abstract.- In a two-stage FEL long wavelength (~100-1000 μm) radiation is produced using a wiggler magnet. The long wavelength radiation then serves as the pump field to produce short wavelength (~1-10 μm) radiation by scattering from a low energy (~3 MeV) electron beam.

To obtain the very high pump field intensities (~10^7-10^9 W/cm^2) required for this application, the long wavelength radiation must be contained in a low loss resonant cavity. A long narrow interaction region is needed in which the electron beam can interact with the high intensity pump field, but the pump beam diameter must be large at the cavity end mirrors to prevent mirror damage.

A quasioptical cavity design that meets these requirements is shown below. Long wavelength radiation reflected from the large cavity mirrors is focused down at the entrance to a waveguide. The waveguide provides a long region of uniform cross section for the FEL interaction to take place. After leaving the waveguide the long wavelength beam expands by diffraction. The short wavelength beam suffers almost no diffraction and passes through holes in the cavity end mirrors.

The lowest loss waveguide mode in this system is the cylindrically symmetric annular TE_{01} mode. Because this mode has a minimum on axis and at the walls of the waveguide, losses are minimal at the holes in the mirrors and in the waveguide. By segmenting the waveguide all modes except TE_{01} modes are suppressed and an axial electric field can be imposed in the waveguide to optimize gain in both the first and second stages of the FEL. Polarization of the TE_{01} mode is linear but varies with azimuth angle. A helical wiggler is therefore needed to fully excite the TE_{01} mode. The system would operate most efficiently using an annular electron beam to interact with the annular pump field intensity pattern.

An electron beam with low emittance and energy spread first passes through the second stage interaction region in which a small energy spread is induced on the beam. It then enters the wiggler where long wavelength radiation is preferentially produced. The energy spread from the second stage interaction should be a negligible perturbation for the first stage interaction.