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HOLE COUPLED RESONATORS FOR BROADLY TUNABLE INFRARED FREE ELECTRON LASERS*

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Abstract

We discuss the performance of two mirror resonators with holes for output coupling, which is interesting for broadly tunable free electron lasers (FELs) in the infrared region. The mode profiles inside and outside the cavity, the diffraction losses at the mirror edges and intracavity apertures, the amount of useful power coupled through the holes, e.t.c., are calculated for several lowest loss azimuthal and radial modes for different resonator configurations. The FEL interaction is modeled by constructing a transfer map in the small signal regime and incorporating it into the round-trip transfer map of the resonator. A simple saturation model based on the linear map is used for steady state calculations. An important observation is that modes could become degenerate for certain resonator configurations, which must be avoided for a stable FEL operation. It is found that the FEL gain is very effective in breaking the degeneracy between the azimuthally symmetric class of modes. However, a suitable passive mode control is necessary to suppress the unwanted higher order azimuthal modes. Schemes for broad wavelength tuning based on passive mode control via adjustable intracavity apertures are discussed.

An experimental study of the hole coupled resonators (neglecting the FEL gain effects) may be conveniently carried out in a set-up where a resonator with properly scaled dimensions are continuously injected by a He-Ne laser. The mode content under this circumstance is calculated and analyzed in terms of the eigenmodes of the cavity. It is found that the steady state profile of a continuously injected cavity can be made close to that of the eigenmode by properly adjusting both the round trip phase factor and the transverse profile of the injected laser beam.

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