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Wakefields in Photonic Crystal Accelerator Cavities[1]

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The RF properties of photonic crystals (PhCs) can be exploited to avoid the parasitic higher order modes (HOMs) that degrade beam quality in accelerator cavities and reduce efficiency and power in RF generators. For example, an accelerator cavity can be designed using a PhC structure that traps only modes within a narrow frequency range, so that the cavity has only a single mode. Although the lack of HOMs is perhaps the most drastic difference between PhC cavities and traditional metal cavities, PhC cavities should allow a much wider range of materials and shapes, which could potentially lead to cavities that operate at higher electric fields and at higher frequencies (with lower losses). However, this greater flexibility introduces many challenges for building actual structures. A hybrid cavity that uses a dielectric 2D PhC along with metal plates to trap fields in the third dimension may offer the advantages of a PhC cavity while being relatively easy to construct. Although the 2D photonic structure may allow only a single mode, the 3D structure can in principle trap HOMs, such as guided modes in the dielectric rods that form the PhC; however, computer simulations show that long-range wake fields can be significantly reduced in such hybrid structures. For a 3D cavity based on a triangular lattice of dielectric rods, the rod positions can be optimized (breaking the lattice symmetry) to reduce radiation leakage using a fixed number of rods; moreover, the optimized structure can further reduce the wake fields.

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