Dust Studies in DIII-D Tokamak*

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Studies of naturally occurring submicron dust using Mie scattering from Nd:YAG lasers and video data of injected micron-sized dust on DIII-D have provided the first data of dust sources and transport during tokamak discharges. Dust, commonly seen in present fusion devices, poses serious safety and operational concerns for D-T burning devices such as ITER. During normal operation on DIII-D dust observation rates are low, a few events per discharge or less. The net carbon content of the dust corresponds to a carbon atom density a few orders of magnitude below the core impurity density. Statistical analysis of Mie data collected over months of operation reveal correlation of increased dust rate with increased heating power and impulsive wall loading due to edge localized modes (ELMs) and disruptions. Generation of significant amounts of dust by disruptions is confirmed by the camera data. However, dust production by disruptions alone is insufficient to account for estimated in-vessel dust inventory in DIII-D. After an extended entry vent, thousands of dust particles are observed by cameras in the first 2-3 plasma discharges. Individual particles moving at velocities up to ~300 m/s, breakup of larger particles into pieces, and collisions of particles with walls are observed. After ~70 discharges, dust levels are reduced to a few events per discharge. Large flakes capable of causing a disruption are occasionally (though very rarely) observed. Micron-sized dust has been injected into DIII-D ELMing H-mode discharges using the divertor materials evaluation system (DiMES). When magnetically diverted plasma is swept onto DiMES, ~2% of the total dust carbon content penetrates the core plasma, raising the core carbon density by a factor of 2-3. Following injection, dust trajectories in the divertor are mostly in the toroidal direction, consistent with the ion drag force. Dust from the injection is observed in the outboard midplane by a fast framing camera. The observed trajectories and velocities of the dust particles are in qualitative agreement with modeling by the 3D DustT code.

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