Measurements and modeling of dust dynamics and radiative mantle

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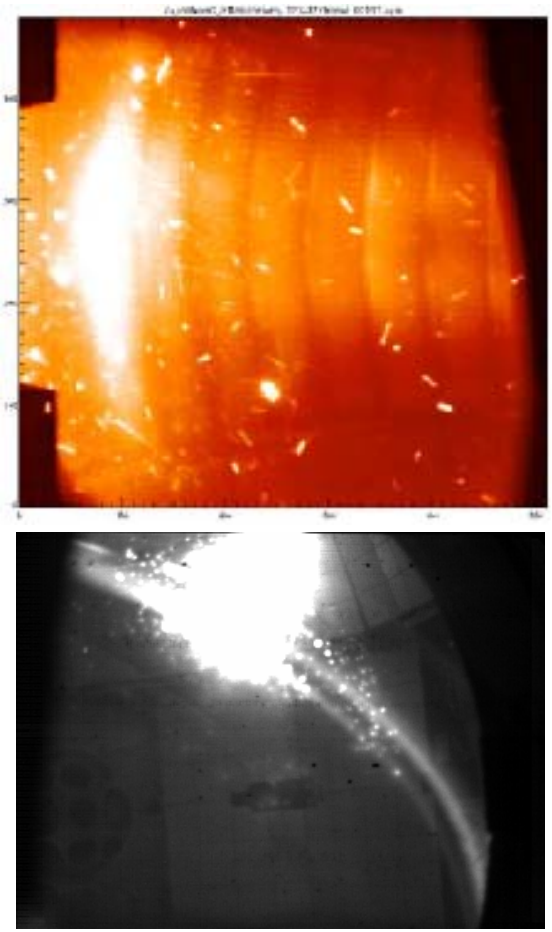
Background

- natural and artificial dust can modify plasma parameters due to introduced impurities
- dust can be used for wall conditioning, disruption mitigation, plasma diagnostics
- accumulation and mobilization of in-vessel dust can present safety issues for future fusion reactors
- dust can retain and release hydrogen (tritium)

Natural carbon dust and injected Li dust in NSTX*

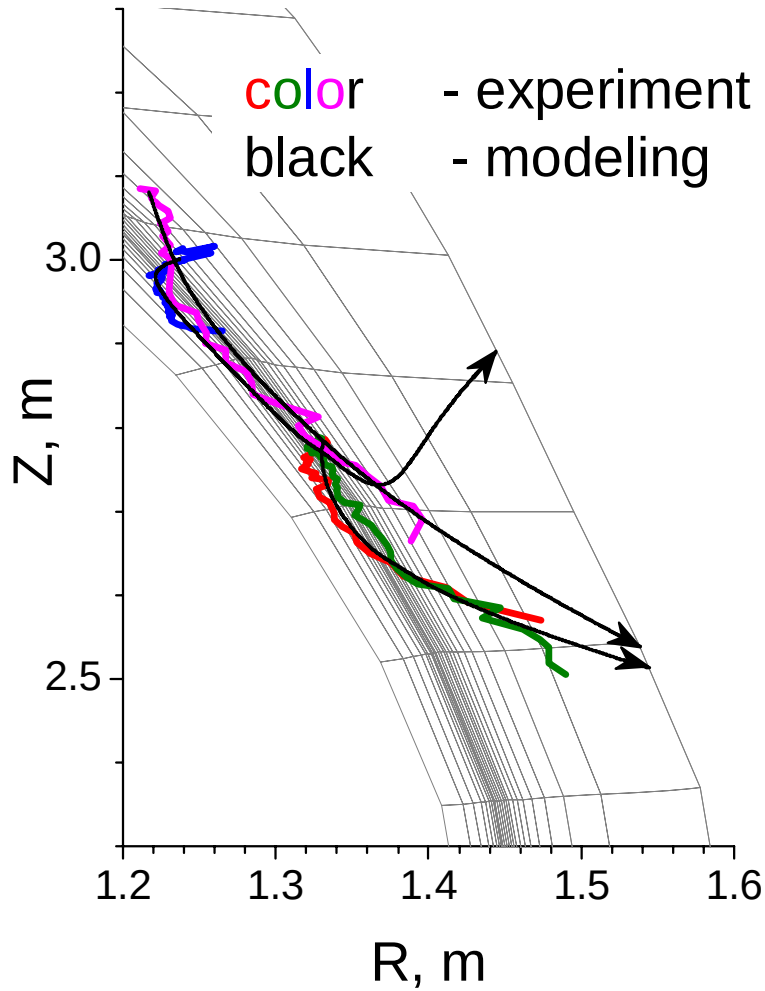


* A. L. Roquemore, et. al., J. Nucl. Materials **363-365**, 222 (2007); D.K. Mansfield, et al. APS-2009

Dust dynamics

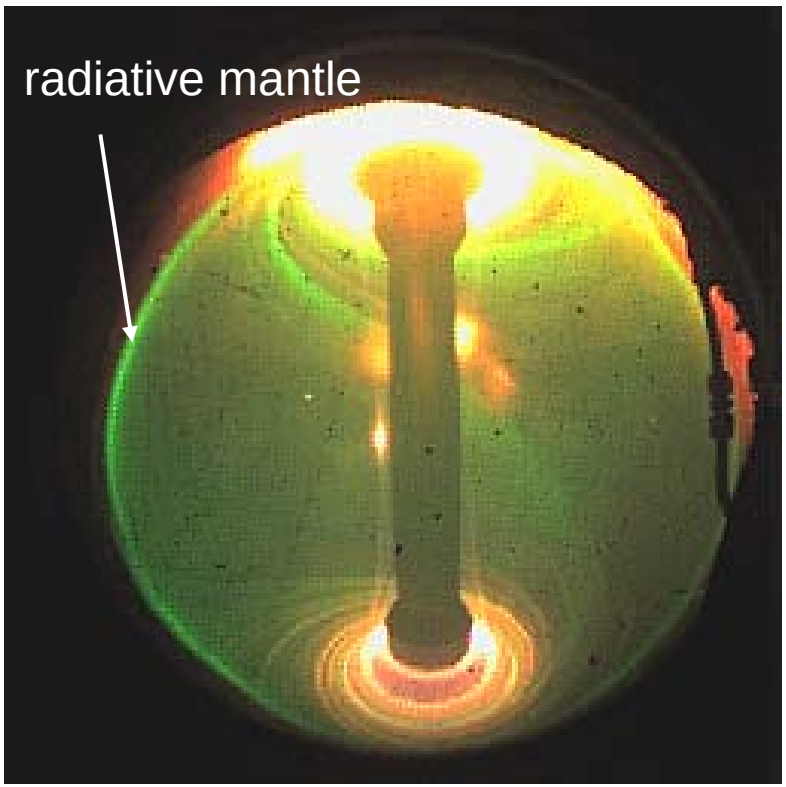
- Recently obtained experimental Li dust trajectories are compared with the DUSTT simulated trajectories using plasma parameters modeled by UEDGE
- Main findings:
  - lithium ablation cloud significantly reduces heat flux to the dust grains as compared to un-shielded dust models (may be not so for W dust)
  - local plasma parameters can be affected by massive dust injection
  - cross-field trajectory variations can be caused by forces associated with non-uniformity of dust shapes and composition

Sample dust trajectories



Radiative mantle

Visible radiation from massive Li dust injection*



- DUSTT/UEDGE modeling indicated that individual 22micron Li dust grains can reach primary separatrix due to the ablation cloud shielding effect
- Dropping large amount of Li dust may change substantially the SOL properties and lead to change in the dust ablation profile and plasma/impurity transport in SOL
- Quiescent (no ELMs) radiative plasma mantle is observed in SOL when dropping >70mg/s of Li dust

* D.K. Mansfield, L. Roquemore, H. Kugel et al. APS-2009

Proposed experiments

- We propose injection of dust grains in NSTX plasmas with simultaneous diagnostic of dust dynamics and plasma parameters (fast camera with/without filters, Thomson, and spectrometer diagnostics can be used):
  I. Injection of small amount of Li and W dust of different sizes to determine minimal visible dust sizes, primary source of dust radiation (thermal or ablation cloud), and estimation of the ablation cloud shielding effects (Li and W comparison);
  II. Separate injection of carbon spheres and flakes of similar sizes for comparative analysis of dust trajectories and identifying role of grain shapes in dust dynamics;
  III. Injection of bi-material dust for evaluation of the “rocket” force effects on dust dynamics; a pair of materials with similar composition, but significantly different vaporization temperatures can be used, e.g. graphitic carbon and plastic polymer

Proposed experiments (continued)

IV. Injection of lithium dust in amount >70mg/s in SOL with simultaneous diagnostics of plasma profiles and dust dynamics for assessing the mechanism of the radiative mantle formation

- ½ day combined for measurements of trajectories of the different dust grains and ½ day for obtaining the plasma profiles in massive Li dust injection experiment are requested
- The data collected during these experiments will be used to validate and refine models employed in the dust transport code DUSTT, in particular the models for dust shielding and variational forces
- We plan to do self-consistent DUSTT/UEDGE modeling of the massive Li dust injection experiment trying to reproduce and explain the variation of plasma parameters and radiation in SOL