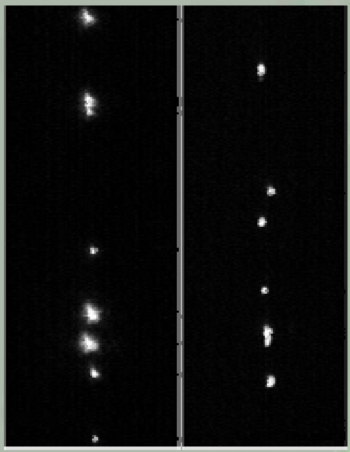
Particle Levitation for Fuels Characterization

Skigh Lewis, Alex Romriell, Dan Jack, and Larry Baxter

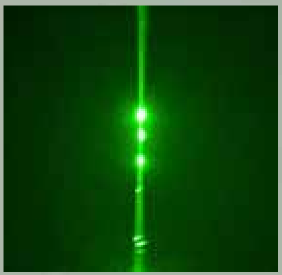
Objectives:

- Establish opaque-particle levitation mechanism
- Observe and model particle reactivity as a function of time, pressure, and gas composition
- Develop *in situ* diagnostics for particle combustion



Experimental Observations:

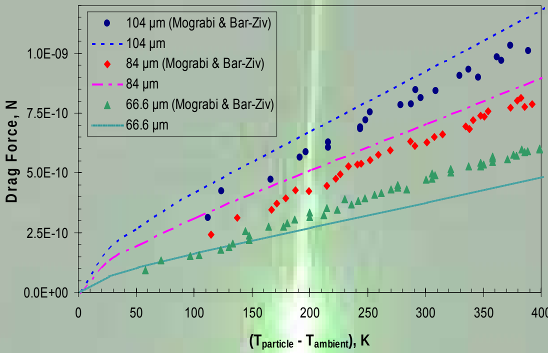
- Ar^+, Nd:YAG, and Nd:YVO_4 laser beams oriented in any direction successfully levitate particles
- Particles with higher emissivities and lower densities levitate more easily
- Wide variety of particles successfully levitated, including aluminum and black liquor (pictured)



Trapping Mechanism:

Drag force:

- Convective drag force estimates agree with experimental data – see right (data from Mograbi and Bar-Ziv, 2005)



Photon Force:

- Photon force estimates from Amsterdam Discrete Dipole Approximation (ADDA)
- Radial component acts as a restoring force to pull particles to center of beam

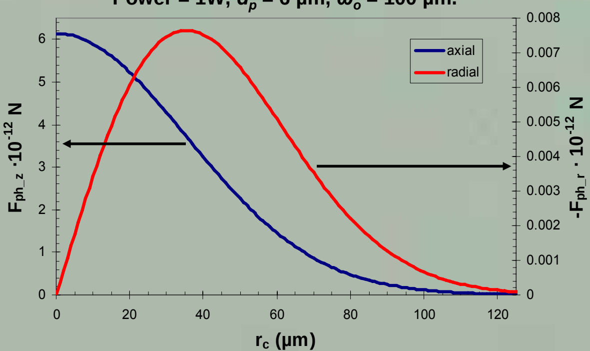
Particle Levitation Model:

- Predicts particle temperature and magnitudes of trapping forces:

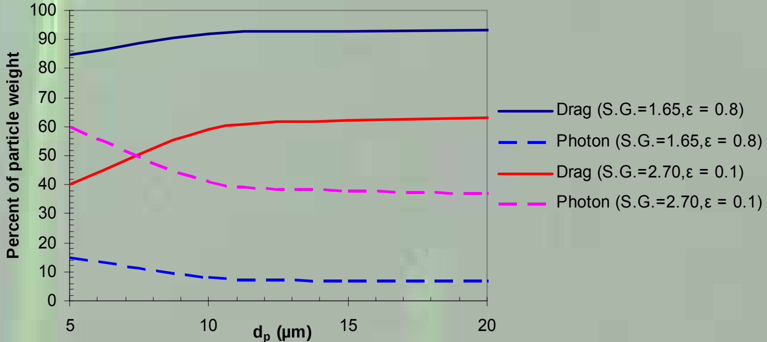
$$F_{drag} + F_{photon} = F_{mg}$$

- Particle temperature is only a function of particle size and emissivity (bottom)
- A given particle reaches the same temperature regardless of beam power
- Drag force dominates trapping mechanism at high emissivities
- Relative importance of photon force decreases as particle size and emissivity increase

Axial and radial photon forces: Power = 1W, d_p = 6 μm, ω_o = 100 μm.



Relative significance of drag and photon forces.



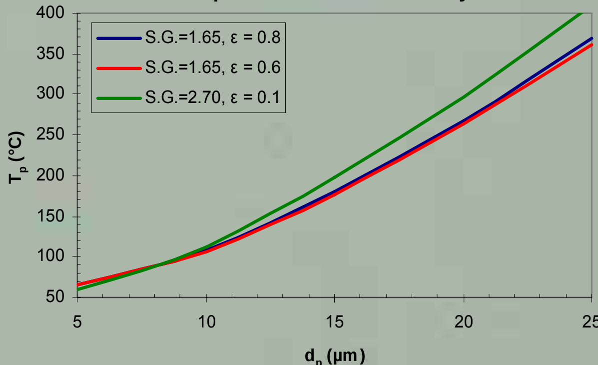
Conclusions:

- Particle levitation model quantitatively describes levitation forces – drag force dominates mechanism for high emissivities

Future work:

- *In situ* tool will measure particle size and temperature during combustion
- Diagnostic may provide cheaper, more accurate, safer, and faster access to gas pressure and composition regimes previously difficult to study

Model prediction of particle temperature as a function of particle size and emissivity.



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