Plasma and Dust-Plasma Environment at Bodies with and without Outgassing

Christine Hartzell
University of Maryland
2018/10/29
Intro to Electrostatic Dust Motion

Neutral Plasma

Plasma Sheath

Equilibrium Current
Surface Potential

Photoemission

Solar Wind and Electron Reimpact
Description of the System

- Surface of an asteroid charges due to interaction with the solar wind ions, solar wind electrons and photoemission of the surface (neglecting any spacecraft charging effects)
- Photoemission current scales with $1/d^2$
- Plasma sheath potential may be monotonic or non-monotonic
- Strong electric fields likely to be present near topographical features causing shadow and sunlight to be in closer proximity

\[ m_d \ddot{h} = qE - \frac{m_d g_s}{\left( \frac{h}{r_c} + 1 \right)^2} \]

\[ \dot{q} = \sum I(h, q) \]
Treecode Plasma Model

- Solar wind flowing in +x direction
- Left half of sphere illuminated

Code Interface:
- Electric field $\rightarrow$ Electrostatic Force
- Species Densities $\rightarrow$ Current

Plasma Model:
Mike Zimmerman, APL
As the production rate (activity) of the comet increases, the distance of the bow shock and ionopause from the nucleus also increases.

**Figure 1.** Schematic diagram of the particles and field environments of an actively outgassing comet (Mendis 1988).
Observability

• Given the solar wind temperatures and velocities assumed for Rosetta, Mendis and Horanyi predicted:
  – well-defined bow shock when $d<1.52\text{AU}$
    • size=3,100km
    • max size at perihelion=15,000km
  – ionopause when $d<1.61\text{AU}$
    • size=1.4km
    • max size at perihelion=25km

• Observations:
  – magnetic field free region at 172km close to perihelion [36]
    Giotto observed (at 0.89AU) the ionopause at 4,300km and bow shock at $\sim 1\text{M km}$ [35]

Figure 3. Heliocentric variation of the nucleo-centric distance of the bow shock, $R_S$, for both the $\gamma = 2$ (continuous line), the $\gamma = 5/3$ (dashed line) cases, and the ionopause, $R_i$, ahead of the comet. The Larmor radius of a picked up cometary ion just ahead of the shock, $L_i$, $10 \times L_i$, and just outside the ionopause, $L_i$, are also shown.
Dust Force Inventory

Relevant to formation of planetesimals and evolution/structure of observed bodies

- Gravity
- van der Waals Cohesion
- Electrostatics
- Solar Radiation Pressure
- Magnetics(???)
- Gas drag
Questions?
Backup