Cometary X-rays

Chandra observations during the last solar cycle

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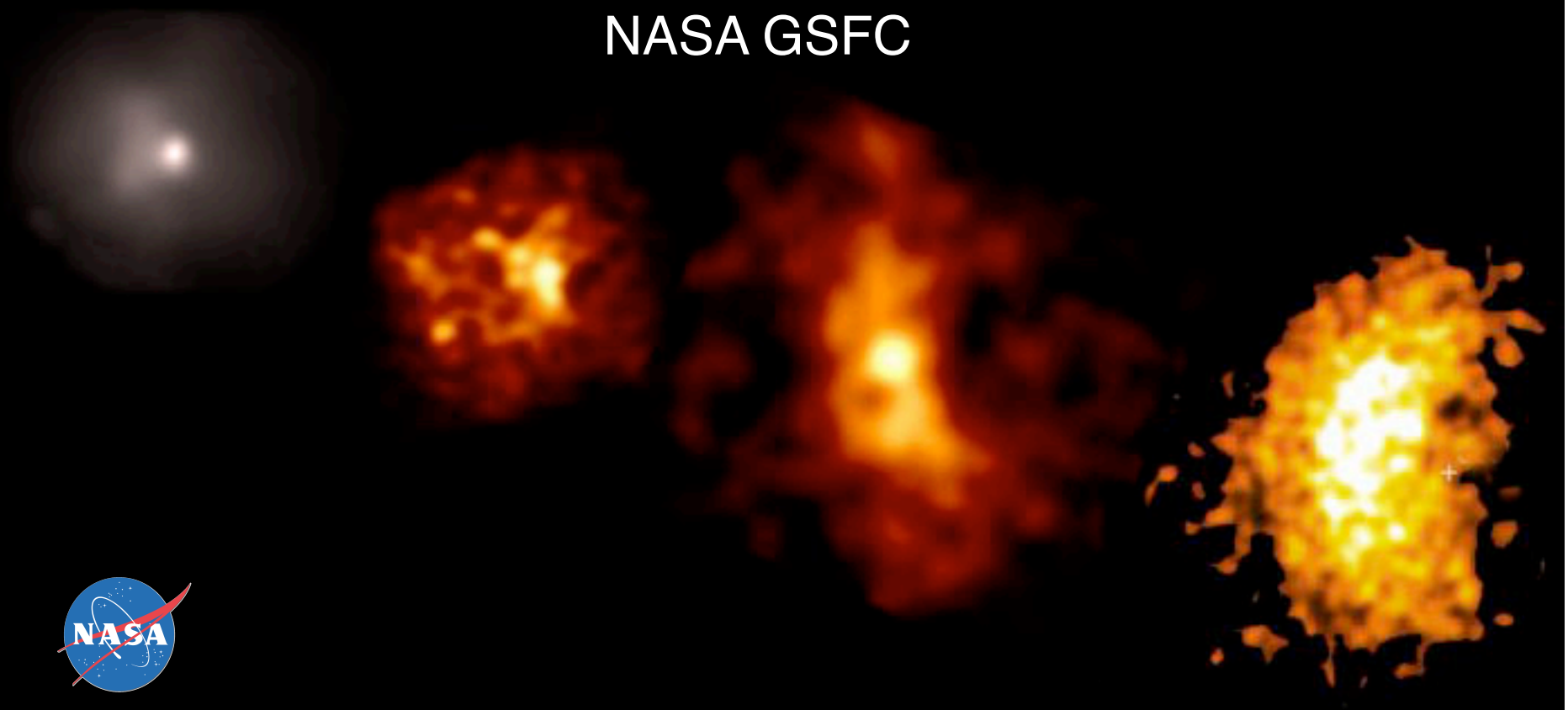
NASA GSFC



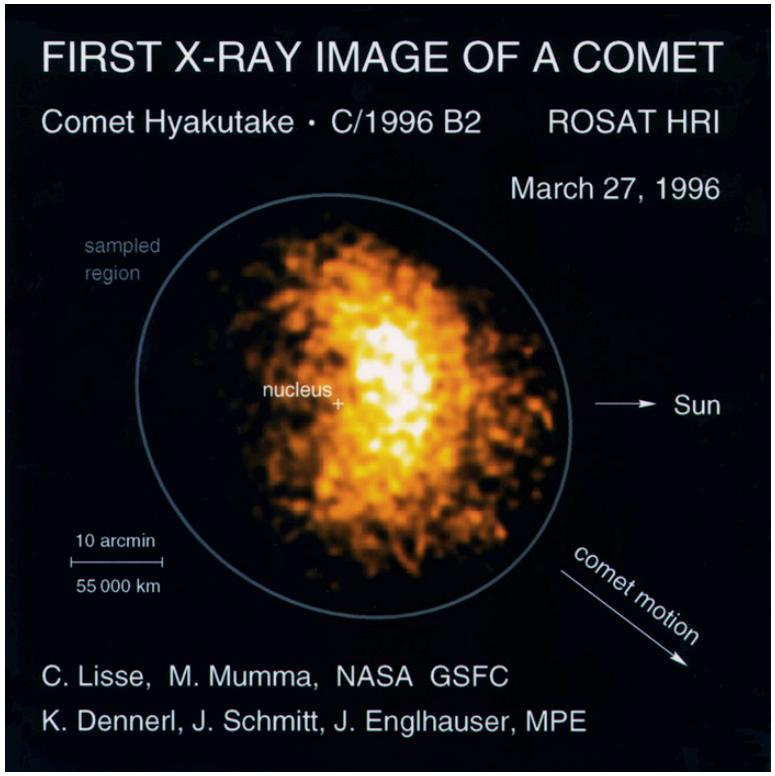
Outline

1. Intro Comets & Solar Wind
2. Chandra & Comets
3. Conclusions

Cometary X-rays

Solar Wind charge exchange

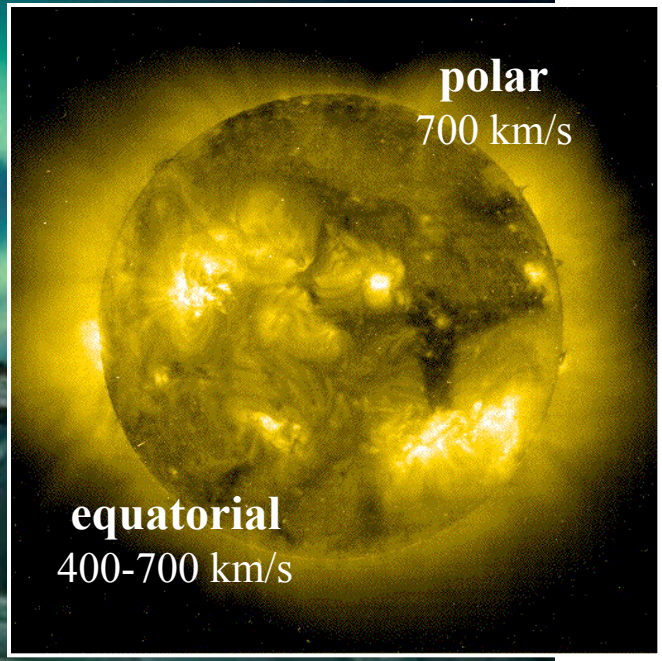
- Bright in X-ray and FUV
- Variable
- Crescent shape
- Common property of (nearby) comets
- 0.2-1 GW
- Line emission



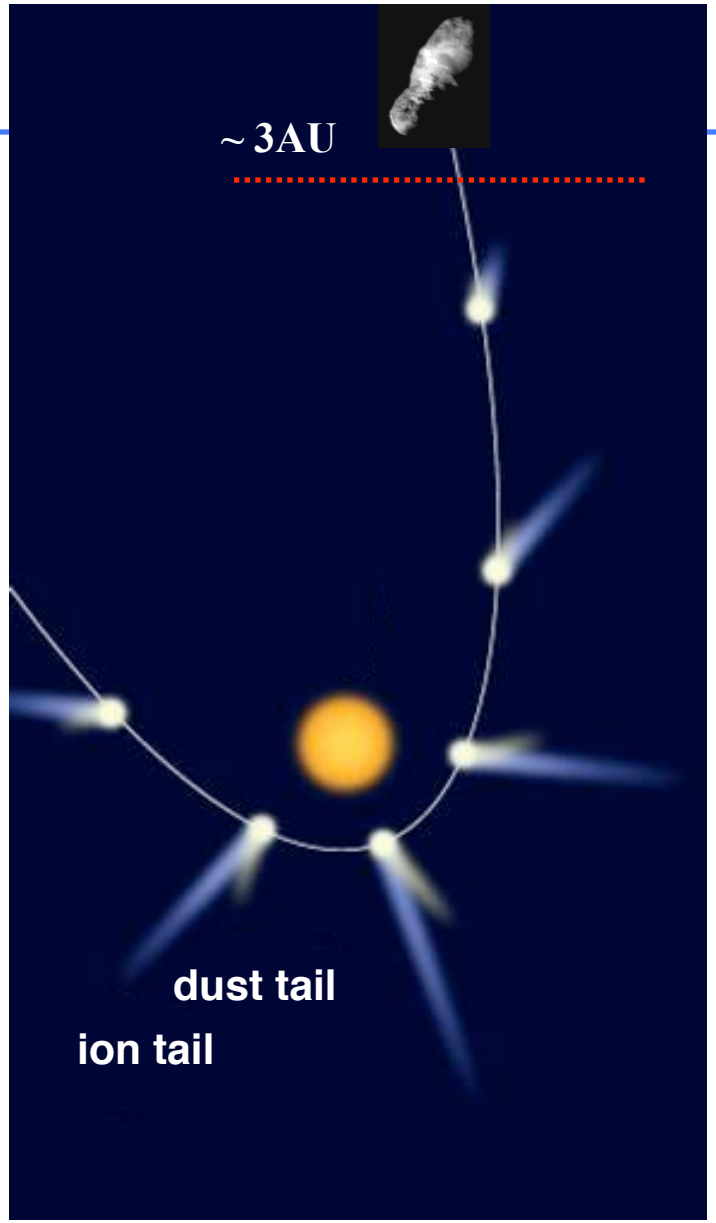
Lisse et al 1996

Solar Wind

- Northern Light!!
- Per cm^3:
  - 9 protons
  - 10 electrons
  - 0.5 He^{2+}
  - few O^{q+},C^{q+},N^{q+},…
- Wind types
- Variability!
- SOHO, ACE, Ulysses
- !DATA AVAILABLE ONLINE!

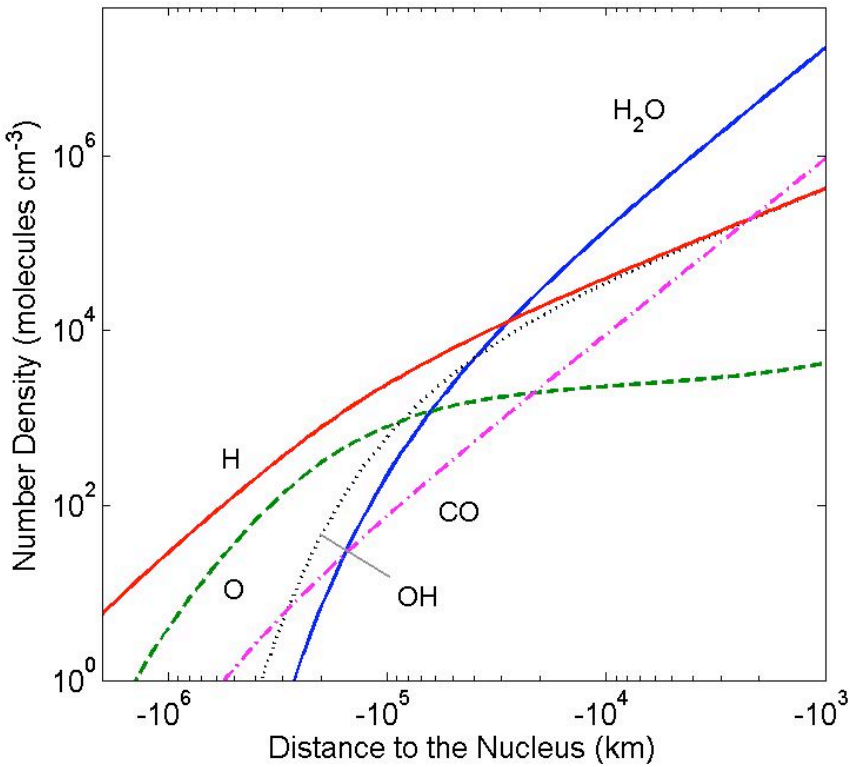


Comets

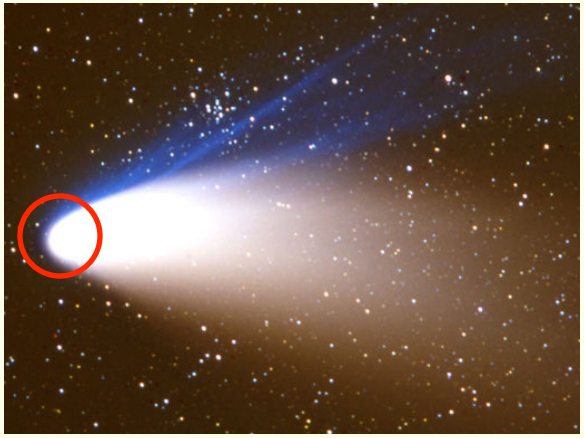


Haser model (Haser, 1957)

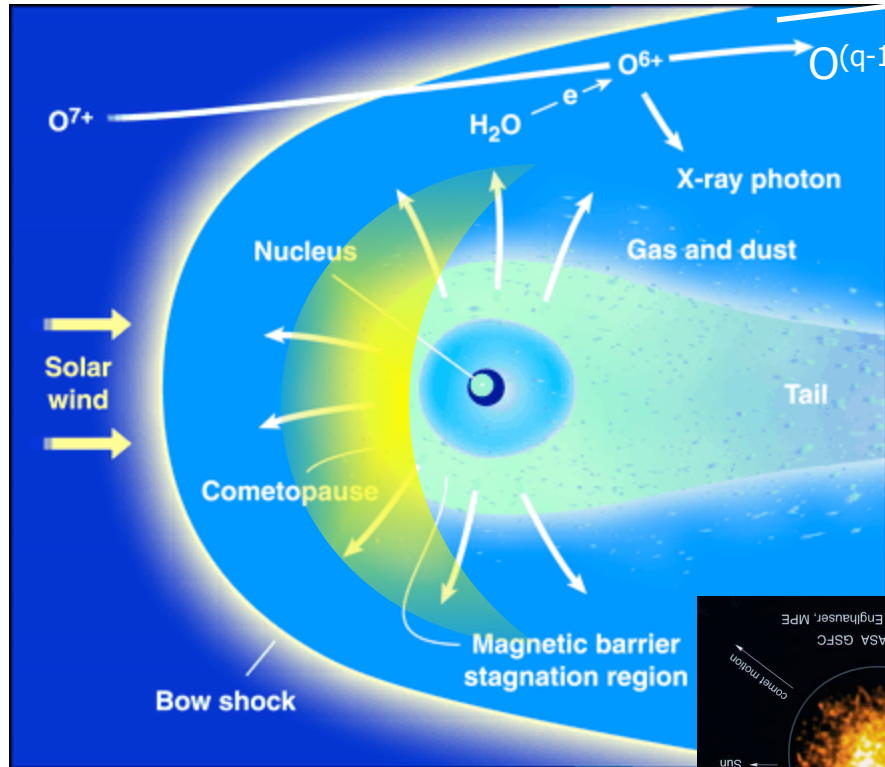
$$n(r) = \frac{Q}{4\pi v r^2} e^{-\frac{r}{h}}$$



Interaction between comet and wind



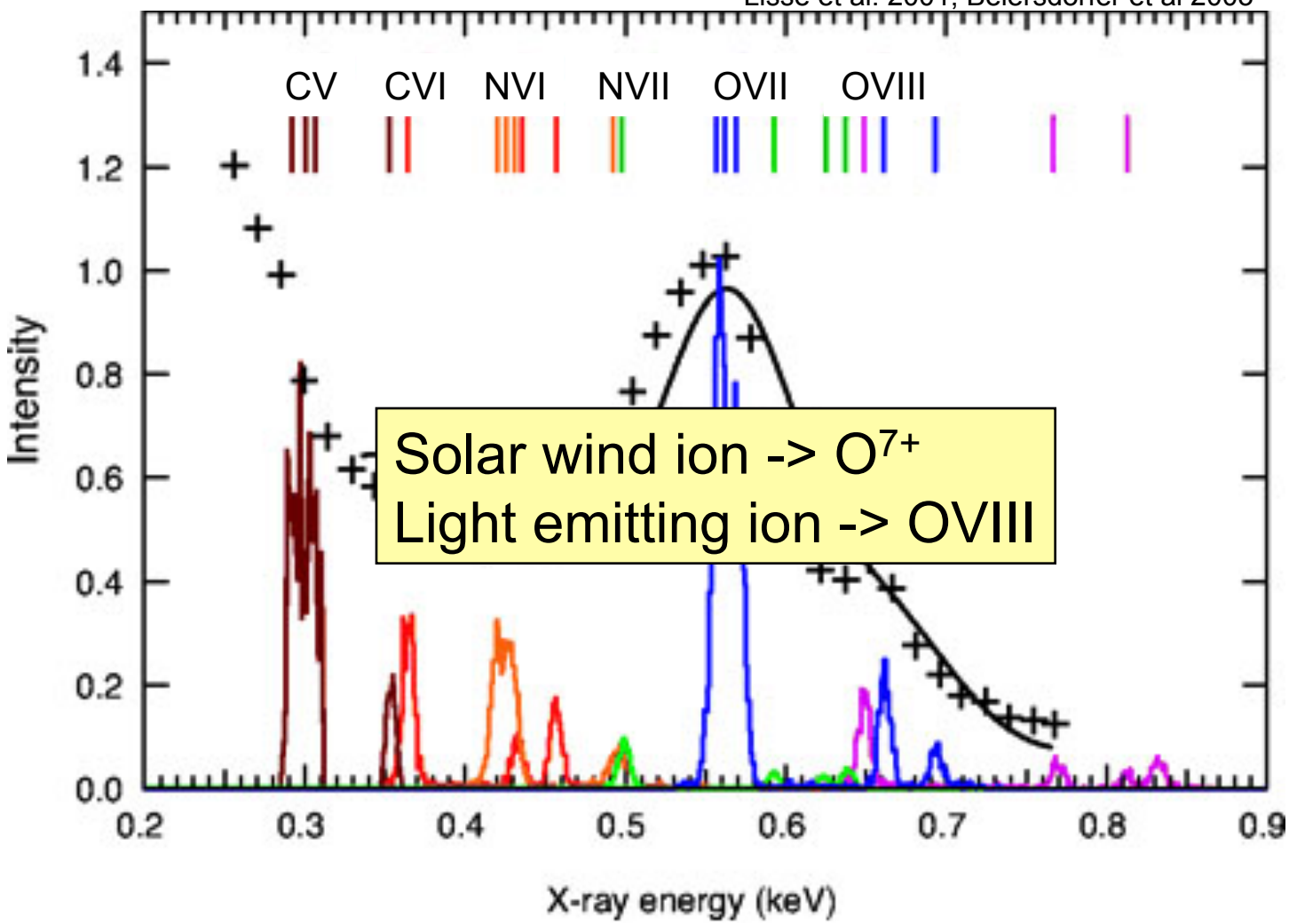
- 10 km Nucleus
- 10^3 km Contact surface
- 10^6 km Bowshock
- 10^8 km Tails



(adapted from Cravens '00)

Spectra

Lisse et al. 2001; Beiersdorfer et al 2003

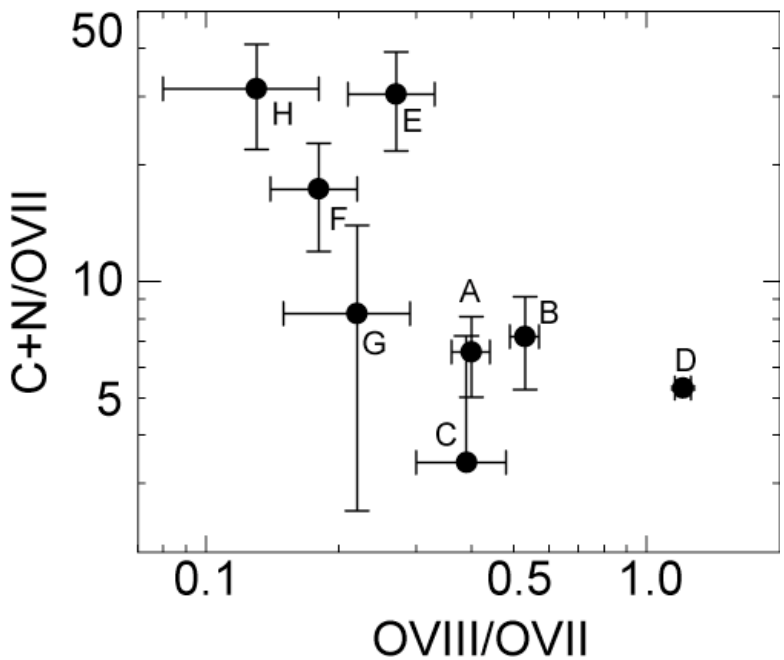


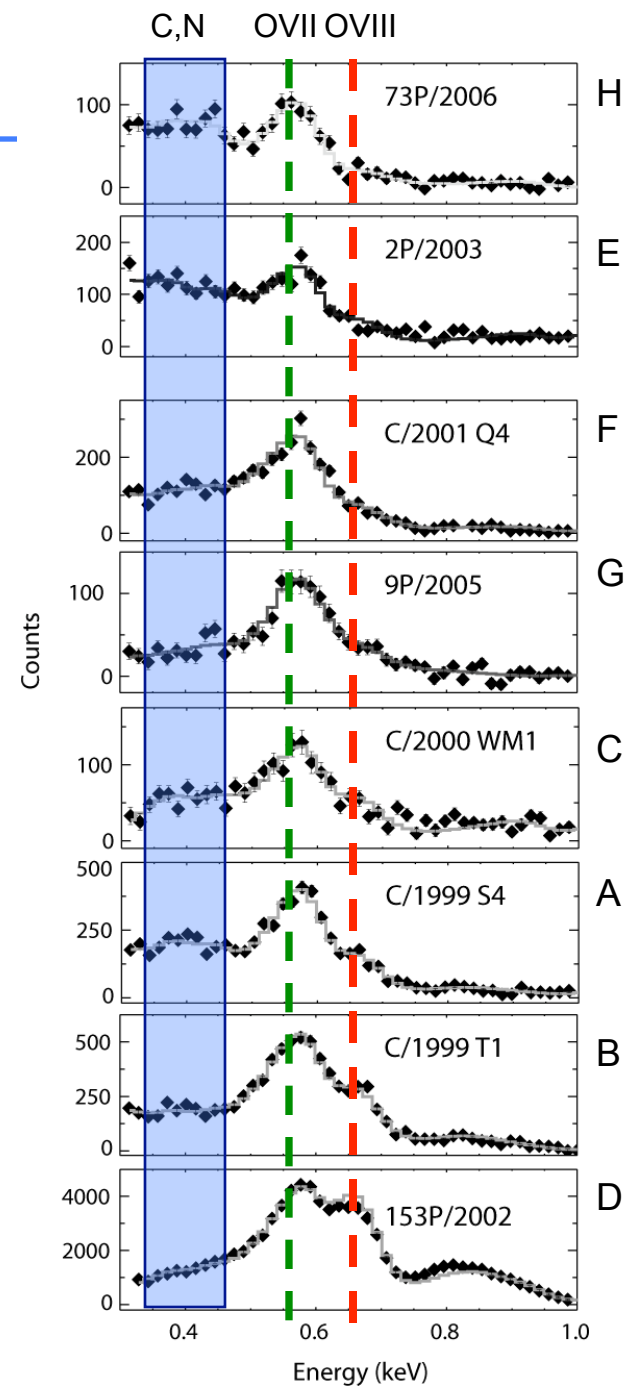
Solar wind ion -> O^{7+}
Light emitting ion -> OVIII

Chandra Comet Survey

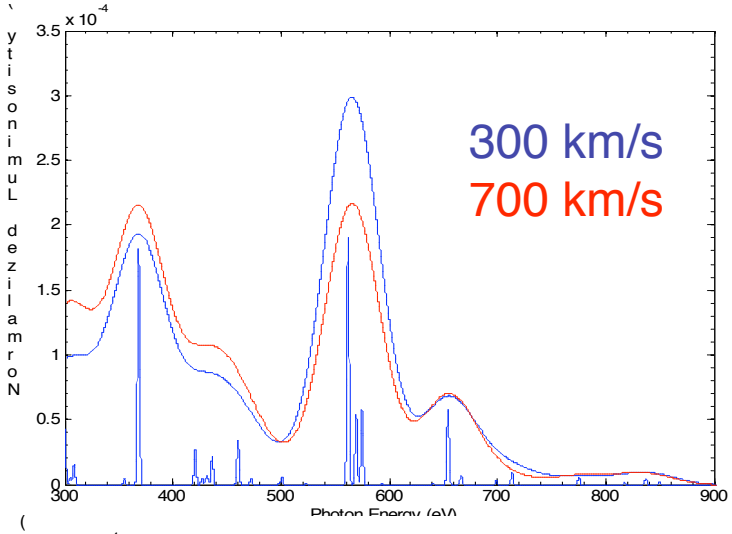
- Chandra ACIS
- 8 comets (10 now)
- 0.3-1.0 keV photons
- 2000 - 2006 (2008)
- Q = $9*10^{27} – 2*10^{29}$/s

- D = 0.1 – 1.4 AU
- R_h = 0.8 – 1.5 AU
- ILatI = 0 – 34 deg
- Phase = 41 – 103 deg



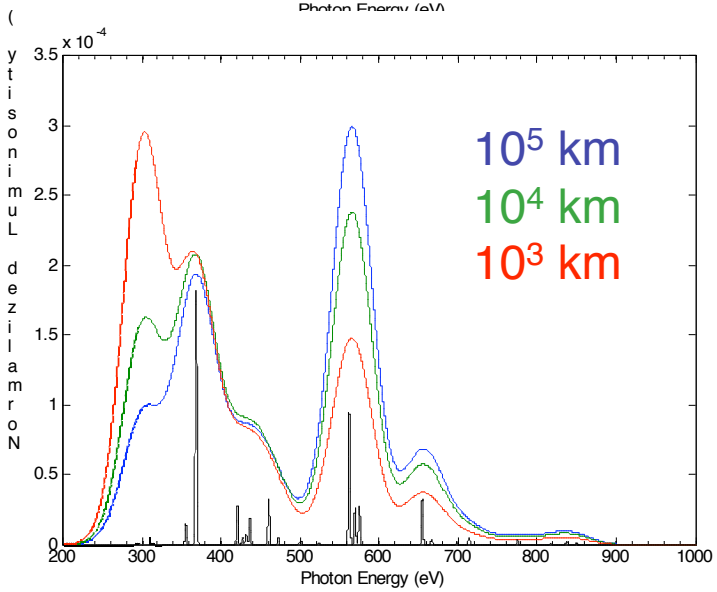


Spectral Shape



Velocity variations

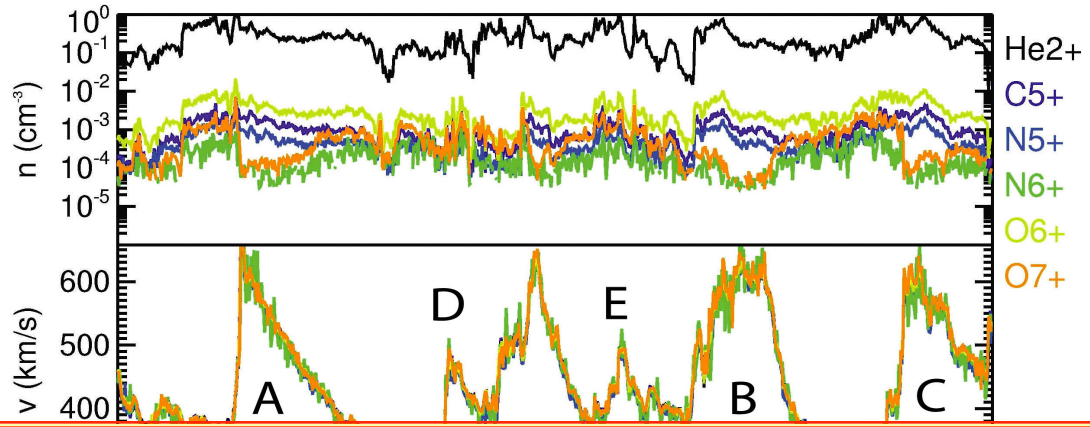
~ factor 1.5



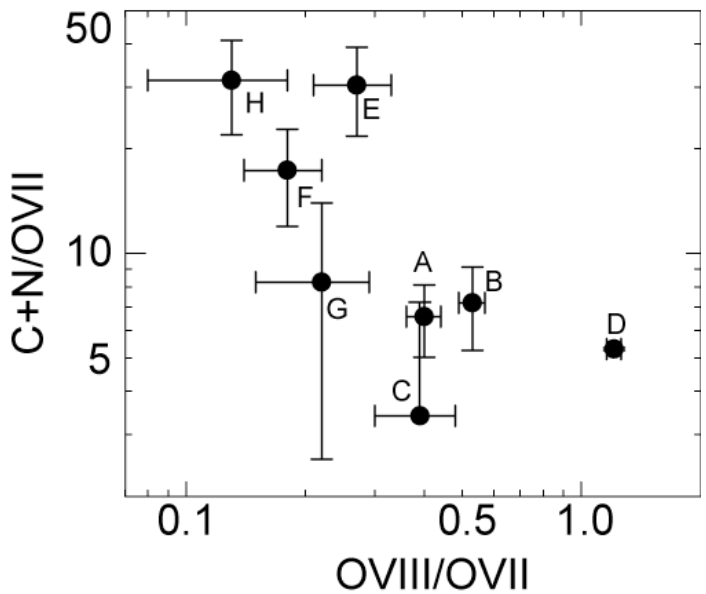
Collisional Opacity

Can be important, but not within this survey

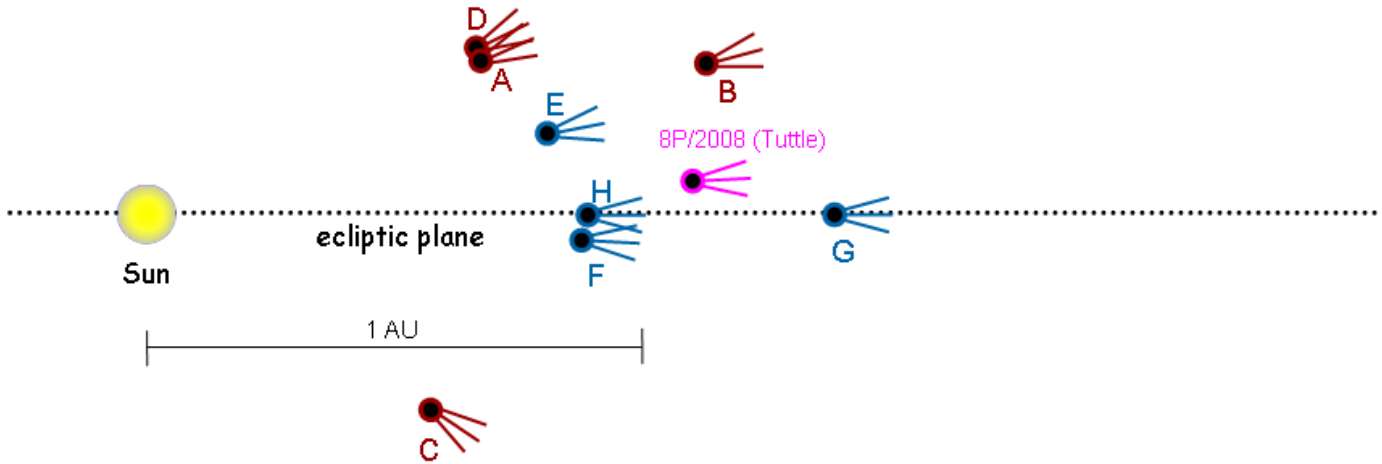
Solar Wind Composition

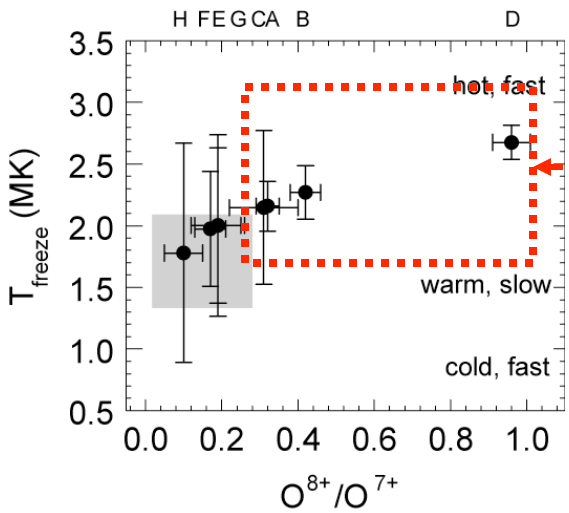


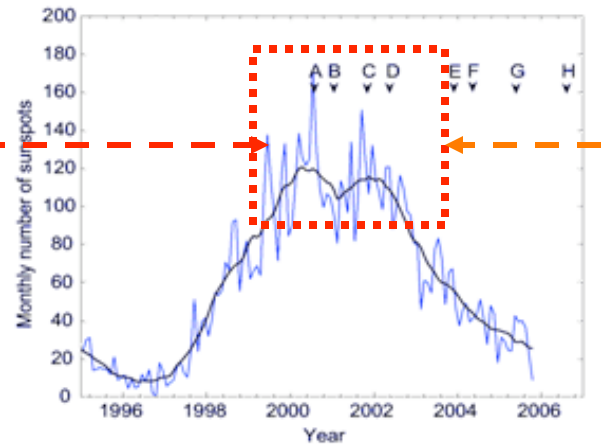
Comet X-ray spectra sample solar wind state

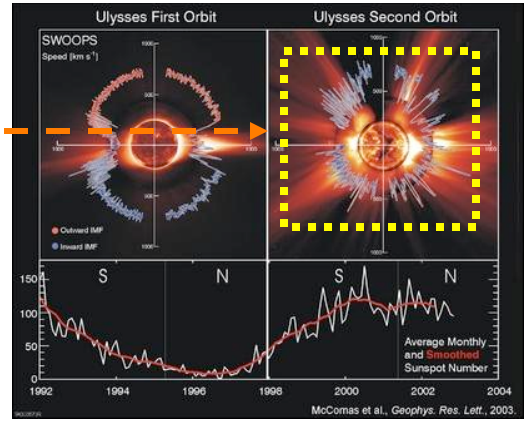


Comets Probe the Solar Wind





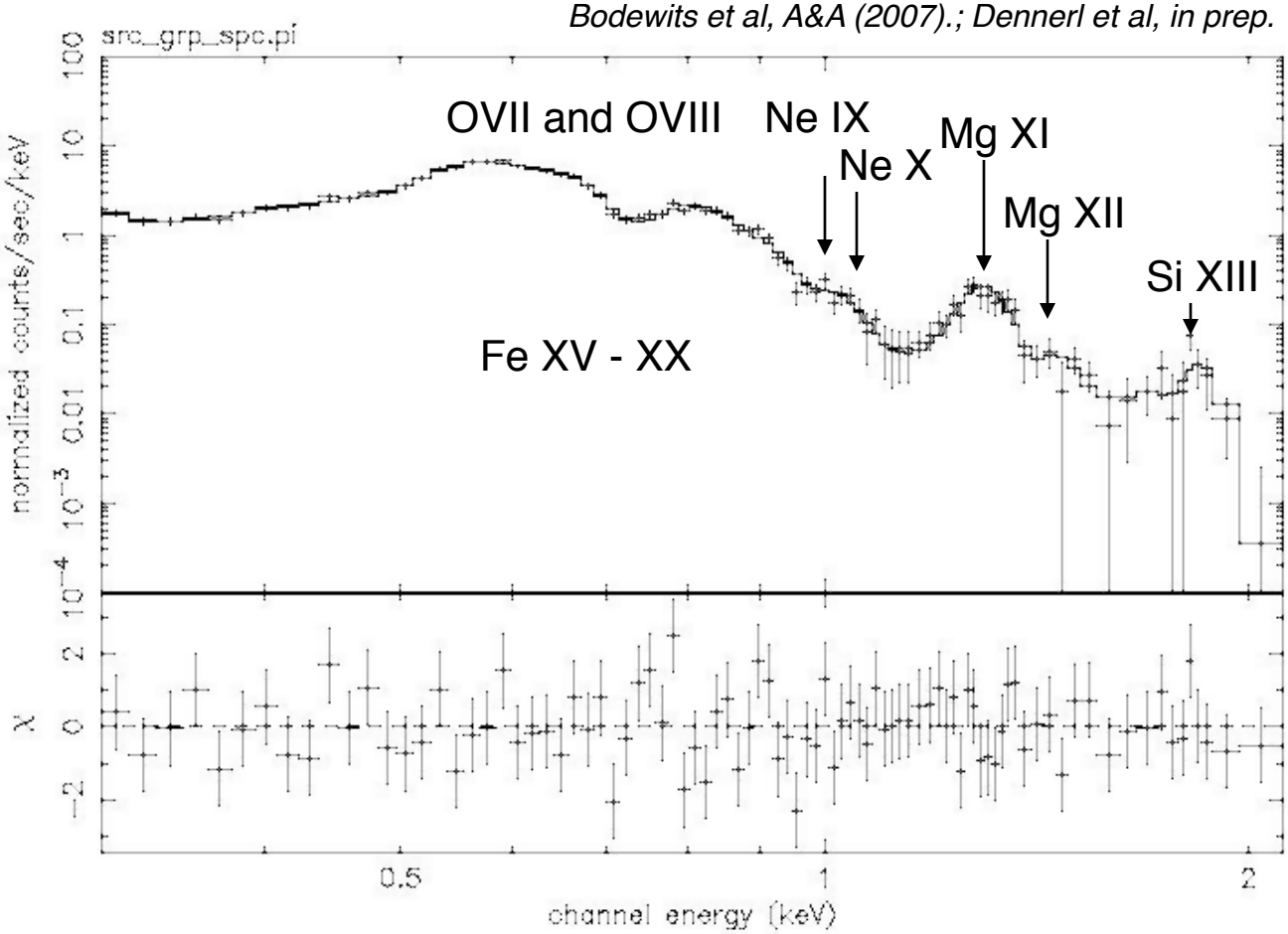




C/2002 C1 (Ikeya-Zhang) + CME

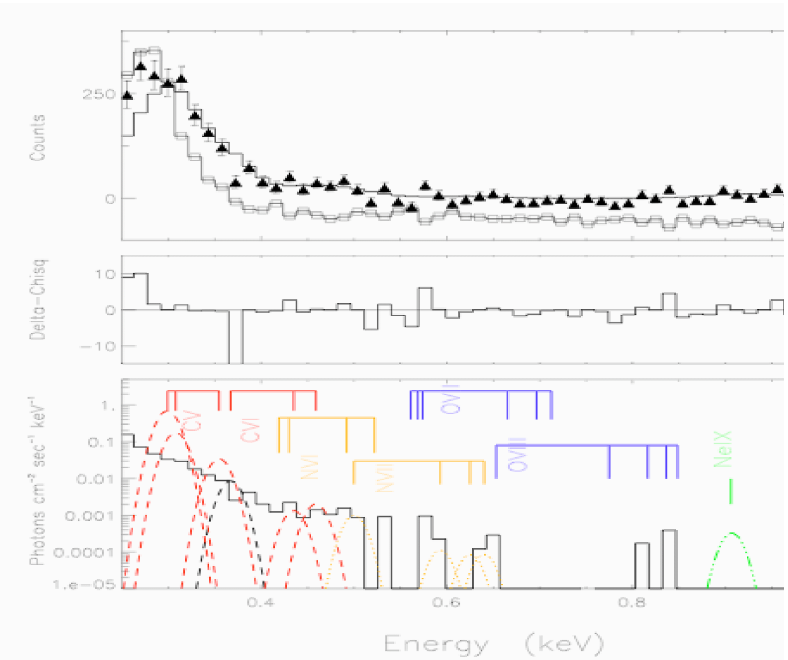
First detection of Mg XI-XII and Si XIII in comet spectrum

Bodewits et al, A&A (2007).; Dennerl et al, in prep.

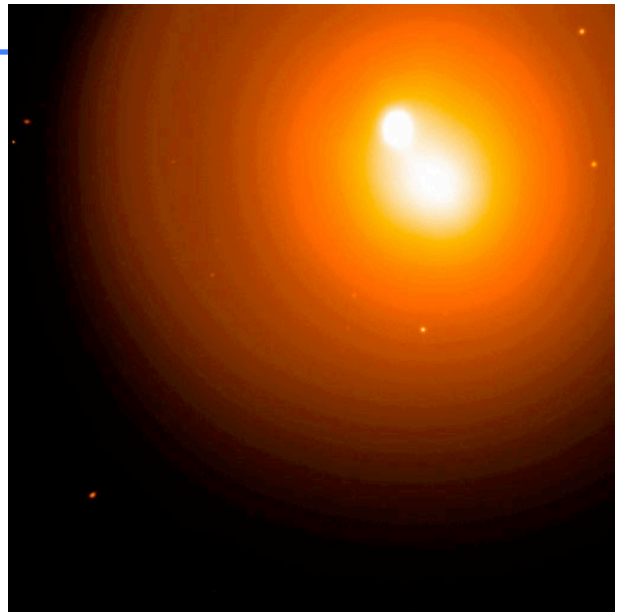


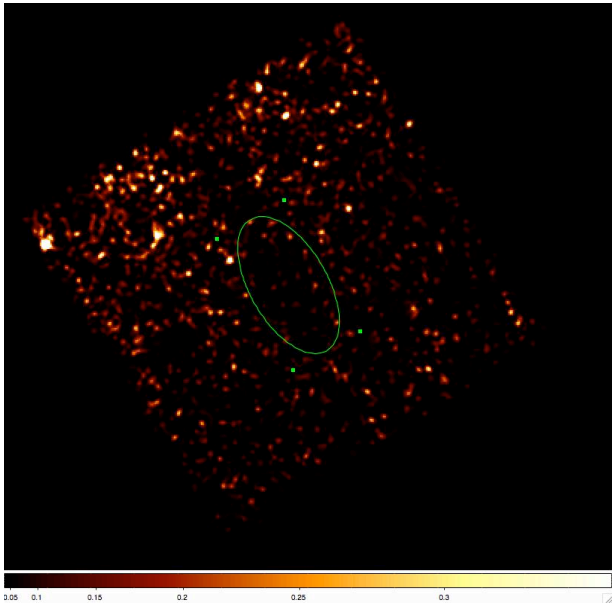
17P/Holmes in polar wind

- Mayor outburst in Oct 2007
- Chandra 31 October 2007
- Q = 5E29 mol/s record
- Rh = 2.54 AU record
- Lat = +19 degrees



Kanata Observatory 7'x7'





Bodewits et al (in prep)

Conclusions

Charge exchange emission provides new window on solar system plasma interactions

- X-ray: H- and He-like C,N,O,Ne,Mg,Si
  - <300 eV?
- Spectra:
  - State solar wind
  - Composition
- EUV: Helium

Charge exchange emission occurs anywhere hot and cold gasses collide

Thank you.

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