Diagnostics of fragment species in the coma

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Whence Comets

• Comets are primitive objects connected to the formation of our solar system.
• They provide the most primitive material available for study in our solar system
• What are **primordial properties** and how are they changed through **evolutionary processes**?
• How can we use what we see to study comets: Physics as a **means**.
• Comets move around the solar system and provide a range of changing conditions. Physics as a **goal**, comets as a **laboratory**.
The cometary spectrum

Fragment/daughter/product species are bright and easily accessible.
Resonant fluorescent emission

$H_2O$ 

$CO_2$ 

$OH$ 

$CO$ 

$H$ 

$1,000,000$ km 

$100,000$ km 

$H_2$
Resonant fluorescent emission

Composite spectrum of 103P/Hartley 2

Swift/UVOT observations of comet ISON

Depends on production rate, heliocentric distance^2, and heliocentric velocity
Narrowband filters single out molecular emission in the coma

Bodewits et al. 2016
Emissive Photodissociation (prompt)
Inner Coma

- Emissive photodissocation > fluorescence within 100 km
- Maps H$_2$O (parent) distribution
- Scales with distance to sun $^2$
- Independent of gas production

Bertaux 1986
Use Emissive Photodissociation to image $\text{H}_2\text{O}$

EPOXI images of 103P/Hartley 2

Emissive photodissociation $\Rightarrow$ higher rotational levels

A’Hearn et al. 2015, La Forgia et al. 2017
Emissive photodissociation $\rightarrow$ higher rotational levels
Measure composition using OI emission

Decay scheme atomic oxygen

Line ratio vs. CO$_2$/H$_2$O content

Adam McKay (2012 – ..)
Rosetta/OSIRIS narrowband filter imaging of gas and dust

Bodewits et al. 2016
Dissociative electron impact excitation

1,000,000 km

100,000 km

H₂O, OH, CO₂, CO, O
Electron impact on H₂O gas
OH: Different excitation processes lead to different spectra.
Dissociative electron impact excitation

- Stops as coma becomes collisionally thick to electrons and cools them < 10 eV
- Depends on local density and photoionization rates

\[ \text{Source Emission Rate} \propto \frac{Q_{gas}^2}{d^3 r_{h}^{3/2} \sigma_{\lambda}(v_e)} \]

Mandt et al., in prep
Far-UV diagnostic of composition

Rosetta/Alice spectrum of 67P

Line ratios varies for different parent species

Feldman et al. 2016
Emission processes

• Prompt emission maps parents: map $\text{H}_2\text{O}$ in near-UV/visible

• Electron impact allows imaging and characterizing of gas composition and local plasma conditions

• Electron impact emission is bright: observe faint activity at large distances?

• Relevant to other small body atmospheres: Europa, Callisto, Ganymede

• Missions and close apparitions allow us to investigate inner coma
  • Wirtanen later this year
Comet 46P/Wirtanen

• Occurs Dec 16, 2018
  • Less than 4 days after perihelion
  • The comet is near its brightest

• Geocentric Distance
  • 0.0775 AU
  • 30 Lunar distances
  • 11.5 million km
  • 7.1 million miles

• 10\textsuperscript{th} closest comet in modern times
  • Few reached naked eye brightness

• ‘Reverse fly-by’

• Workshop about 46P to celebrate Mike A’Hearn:
  College Park, MD, August 6 – 8, 2019
Thank you!

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