What's Eating Ozone? Thermal Reactions between SO_2 and O_3 and Implications for Icy Environments

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Background

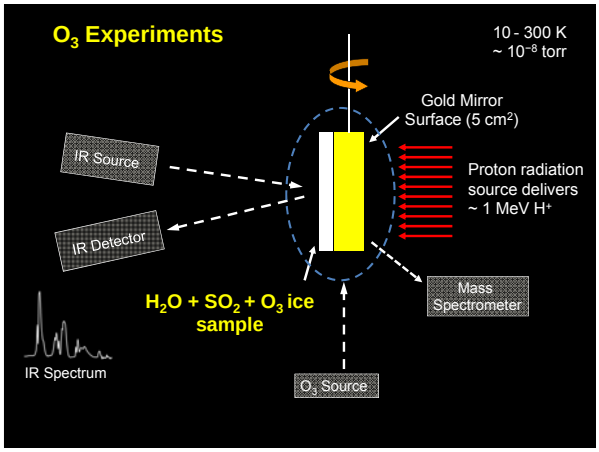
- Surface composition of icy objects can be altered by radiolysis/photolysis
- Laboratory studies show radiolysis/photolysis easily forms ozone (O_3) in many different ices
- Few detections of O_3 via remote sensing
- Why the difference?
  - Could O_3 react with other compounds in the ice?

Where to Start?

- Radiolysis prevalent on the Jovian moons
- Condensed O_2 has been detected on Ganymede, Callisto, Europa
  - O_3 only detected on Ganymede
- Sulfur compounds are present on most Jovian satellites
  - Investigate whether O_3 and SO_2 react in H_2O-ice under relevant conditions

Approach

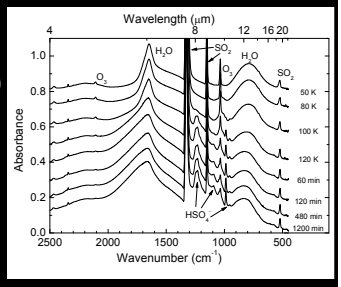
- Grow $H_2O + SO_2 + O_3$ (75-21-4) mixtures at 50 K
- Warm ices, while monitoring with IR spectroscopy
- To synthesize O_3
  - Strike ~100 Torr of O_2 with Tesla coil
  - Trap O_3 in liquid N_2



Results

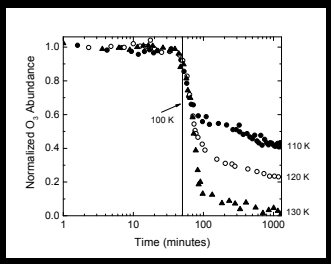
IR Spectra During Warming

- $H_2O + SO_2 + O_3$ ice
  - Deposit at 50 K
  - Warm to 120 K (1 K / min)
- Main Sulfur Products
  - HSO_3^- (80 – 100 K)
  - $S_2O_5^{2-}$ (80 – 100 K)
  - HSO_4^- (> 100 K)



Decrease in Ozone vs. Temp

- Reaction begins near 100 K
- Rate increases with temperature
- At 130 K, O_3 reaches noise level in a few hours
- Temperatures are well within those observed for Jovian icy satellites



Implications for Callisto

- Condensed O_2 on trailing side but no O_3
- SO_2 is present but more abundant on leading side
- O_3 on trailing side would be consumed by SO_2 explaining
  - Lack of O_3 on Callisto
  - Lower abundance of SO_2 on trailing side

Summary and More Implications

- O_3 and SO_2 react readily above 100 K
  - They won't be found in same vicinity
- Callisto
  - Lack of ozone in trailing hemisphere
  - Spatial distribution of SO_2
- Possibly relevant to other icy bodies
  - Mass spectrometer on Rosetta detected O_2 in comet coma but no O_3
  - No O_2 detected in ISM and lower than expected abundance of identifiable sulfur compounds
- Future work will focus on whether other compounds similarly reactive with ozone

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http://science.gsfc.nasa.gov/691/cosmicice/