Nonthermal Ions in the Vicinity of the Moon

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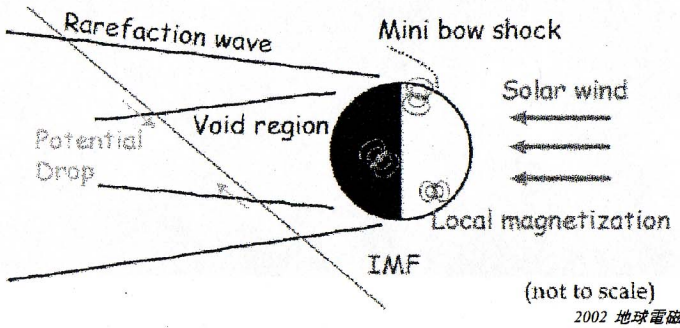

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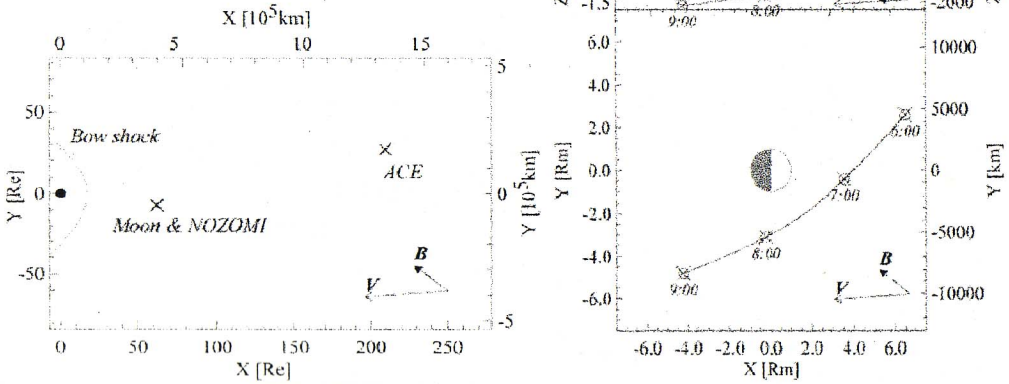
7/22 2002 11:40 AM

Instrumentation

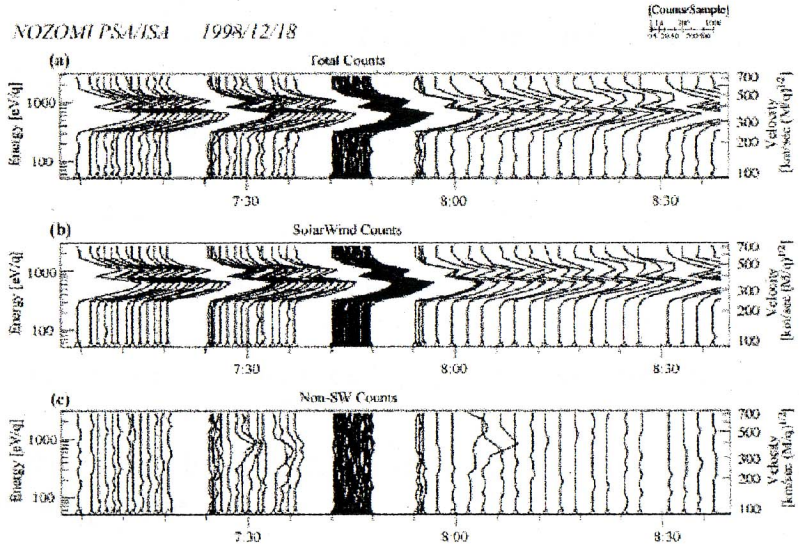
- Particle Spectrum Analyzer/Ion Spectrum Analyzer (PSA/ISA) on board NOZOMI
  - E/q analyzer
  - 3-D distribution function in 1 spin (6.5 sec)
  - 6 eV/q ~ 15 keV/q by 32 steps
  - Omnidirectional view angle with a resolution of 22.5[deg.] x 22.5[deg.]

Locations of Satellite

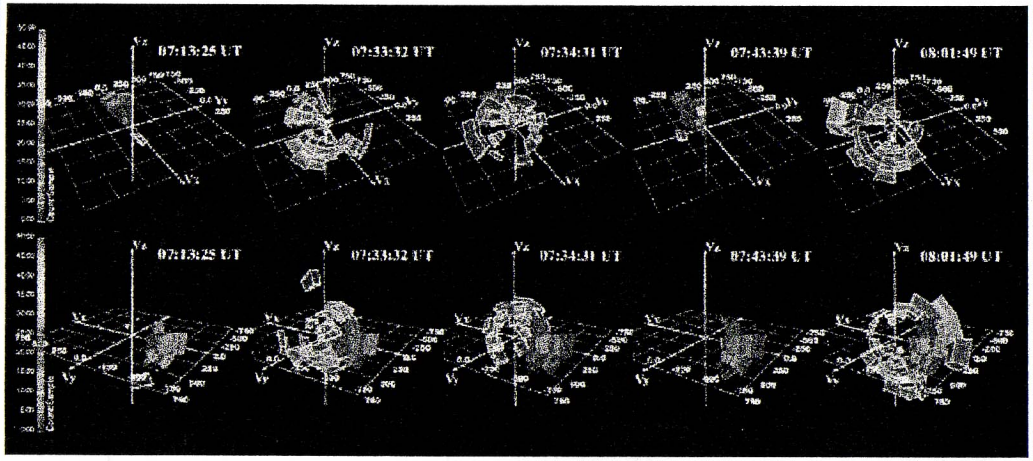
- Moon and NOZOMI are in the interplanetary medium.



Observed Nonthermal Ions



3-D Velocity Distributions

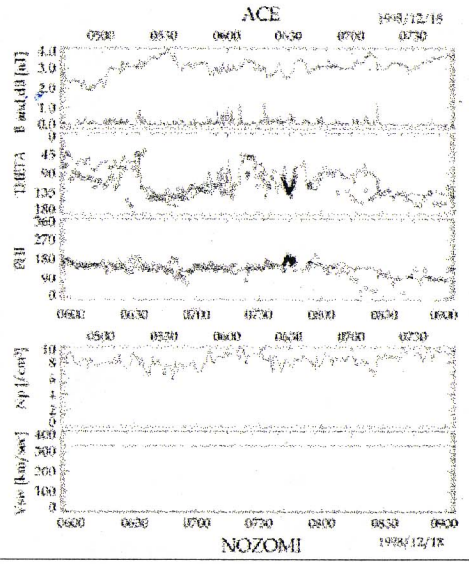


Generation Mechanisms

- Five candidates has been considered.
  1) Solar wind protons deflected by IMF disturbances.
  2) Reflected protons by Earth's bow shock.
  3) Heavy ions escaped from the lunar surface.
  4) Protons generated in the lunar exosphere.
  5) Solar wind protons deflected near the Moon associated with a local magnetic anomalies.

Solar Wind Conditions

- The closest approach of NOZOMI to the Moon occurred at 07:34UT.
- The altitude was 2,800 km.
- Interplanetary magnetic field and solar wind velocity were steady duirng the observation.



Estimation of Mass

- ``Observed" velocities of heavy ions are sqrt(M/q) times larger than ``real" velocities.
  - Observation by PSA/ISA
  - Analysis
  - Results

$$E_{obs} = E_{real} / q = \frac{M m_p v_{real}^2}{2q}$$

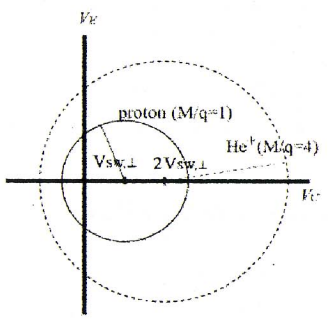
$$E_{obs} = \frac{m_p}{2} v_{obs}^2$$

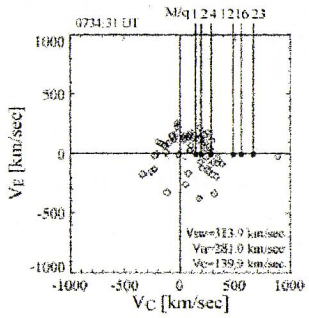
$$v_{obs} = \sqrt{\frac{M}{q}} v_{real}$$

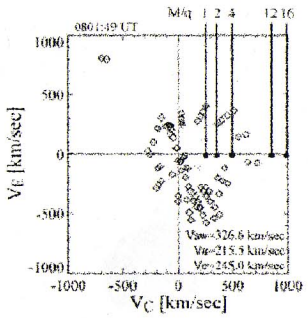
  - The same velocities of ions with different M/q value are divided by PSA/ISA in the ``observed" velocity space.
  - The determination of the ``observed" ExB drift velocity means the estimation of M/q value.
- ``Observed" ExB drift velocity contains the information on M/q value.

Ion Species

- Estimation of ion species is possible by analyzing the energy dependence of ExB drift.
- The species is proton because M/q=1.

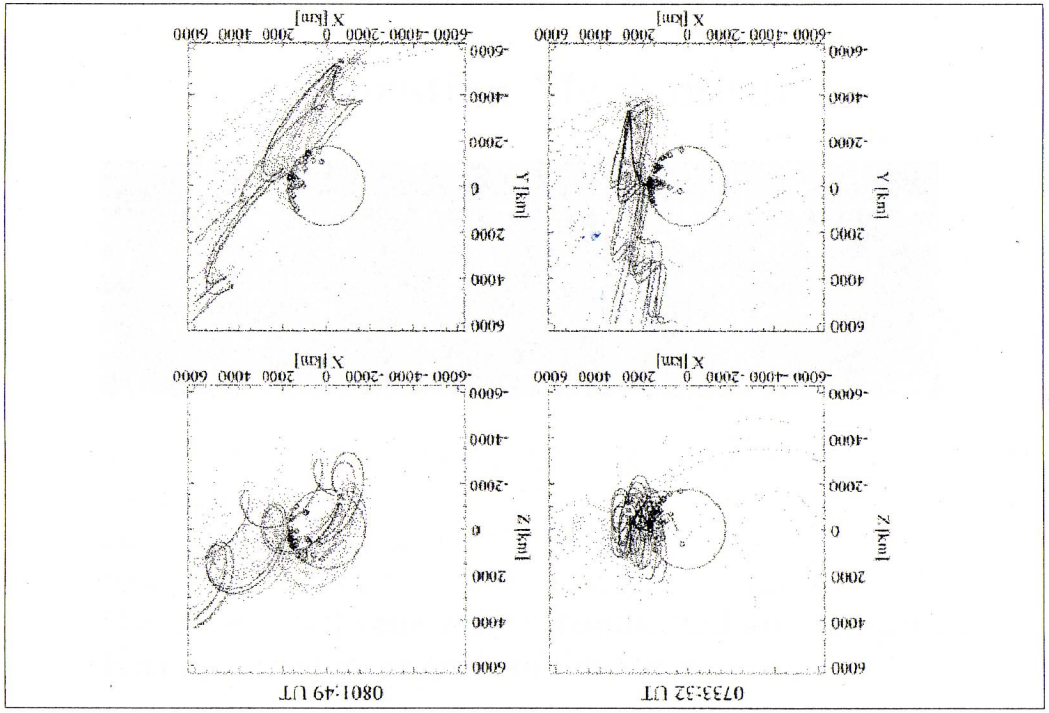


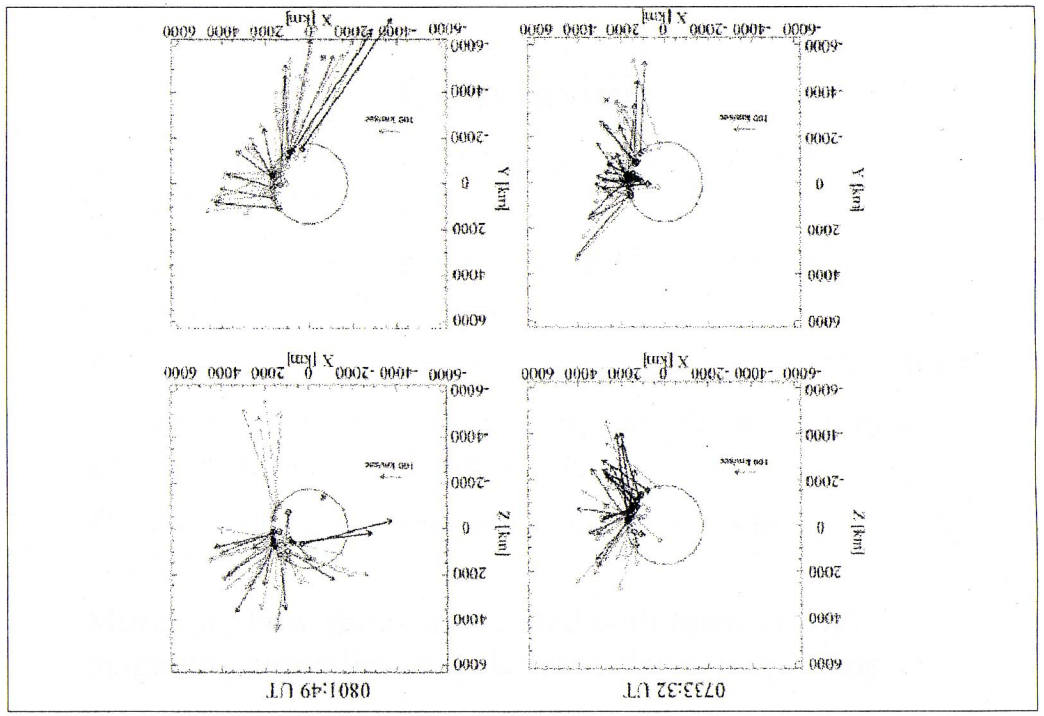




Particle Tracing

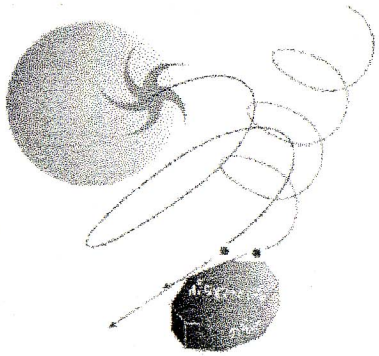
- Assumptions
  - Uniform magnetic field (|B|=3nT)
  - Uniform solar wind velocity (|V|=350 km/sec)
- Results
  - Most of the protons have come from the lunar dayside.
  - Initial velocities of the protons were very large. Some of them exceeded the solar wind velocity.





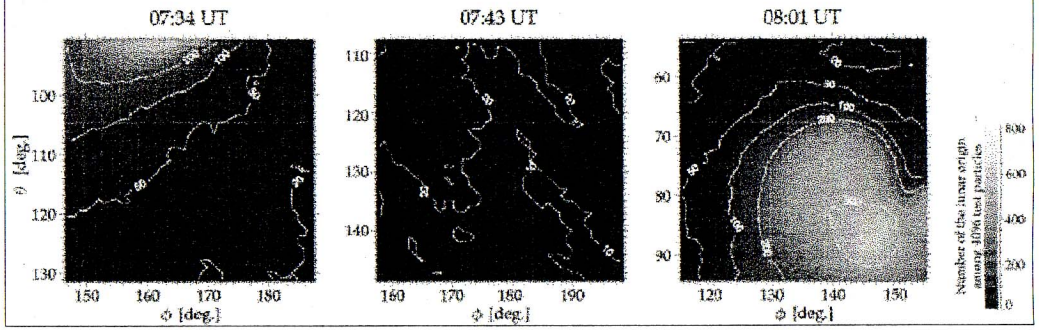
Test Particle Tracing

- Numbers of the test particles of which trajectory is connected to the lunar dayside among 4096 test particles.
  - For the verification of nonthermal component dissappearance.
  - Good parameter of the electric and the magnetic field conditions for the observation of lunar ions
  - 4096 test particles correspond to the ISA's observable velocities
  - Estimation error of the magnetic field (20 degree) is considered

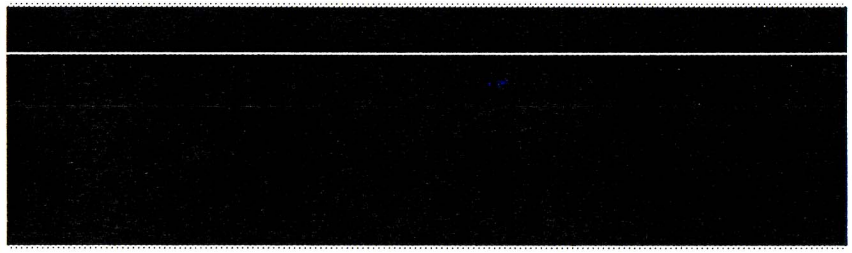


Results of Tracing

- The results are very consistent with the observation.
  - Numbers of potential lunar ions are large for 7:34 UT and 8:01 UT, but are small for 7:43 UT.



Generation Mechanism



- Moon related deflection is the most plausible mechism for interpreting the observation.
- The most possible deflection mechanism is a miniature bow shock associated with the magnetic anomaly.
- The large initial velocities of nonthermal ions indicatte a dynamic structure in front of the Moon.

Conclusion

- Moon related ions have been detected by PSA/ISA on board NOZOMI.
- They were found to be protons and have the partial ring structures in the velocity space.
- Their source was estimated to be the dayside of the Moon.
- They appeared when the electric and magnetic field were good conditions for the observation.
- They must be deflected solar wind protons in the vicinity of the Moon.
- Miniature bow shock associated with lunar crustal magnetic anomalies may deflect solar wind protons.