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Is there solar control of mid-infrared aurora on Jupiter?

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Abstract

Voyager IRIS data and ground-based spectroscopic measurements of Jupiter's northern mid-IR aurora, acquired since 1982, reveal a possible correlation between auroral brightness and solar activity that has not been observed at other wavelengths (Fig. 1). Aurora in Jupiter's polar atmosphere radiates throughout the electromagnetic spectrum, from X-ray through mid-infrared (mid-IR, 5 -- 20 μm wavelength). Auroral emission is excited by energetic charged particles precipitating into the polar atmosphere, powered ultimately by Jupiter's own rotational energy [1], while Jupiter's strong magnetic field shields the magnetosphere from the majority of external influence. Over nearly three solar cycles, auroral brightness measured by 12-micron emission from stratospheric ethane suggests a positive correlation with solar activity measured by the 10.7 cm radio flux and sunspot number. Ethane line emission brightness varies over tenfold between low and high solar activity periods. More frequent and more detailed measurements have been made using the GSFC Heterodyne Instrument for Planetary Wind and Composition (HIPWAC) spectrometer at the NASA IRTF since the last solar maximum, following the mid-IR emission through the decrease in solar activity toward solar minimum. An even tighter correlation with solar activity is evident in these declining-phase data, but with still low overall statistical confidence.

HIPWAC utilizes the infrared heterodyne technique, which measures true line shapes of individual ethane lines in spectral regions between 11.5 and 12 μm, with resolving power $\lambda/\Delta\lambda \geq 10^6$ (wavenumber resolution 0.00003 cm^{-1}) and frequency accuracy 10^{-8}. All data in the period of near 3 solar cycles of measurements were taken with the same technique providing a unique set of data taken and analyzed with no instrumental or computational effects. Analysis of the true line shapes can retrieve both ethane abundance and temperature [4] and nearby minor constituents can be resolved and identified [5]. More current measurements and analyses through 2010 will be presented, including local temperature and ethane abundance variations on and off the north polar "hot spot" region of 180°longitude and 60° latitude. Previous results showed 15-25° temperature increases in the upper stratosphere and over a 3-fold ethane abundance variation between maximum and minimum solar activity times and on andoff the "Hott Spot" [4] (Fig 1).

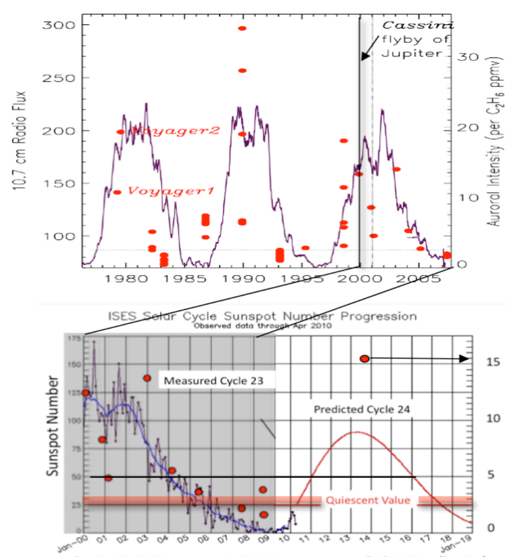

Figure 1: *Top.* Jupiter mid-IR north auroral intensity (red dots) correlates with solar 10.7 cm radio flux (jagged line), an index of solar activity equivalent to sunspot number. High variability and brighter aurora correlate near solar maximum (1979, 1989, 1998–1999; [2], [3]). Auroral intensity is evaluated by equivalent C_2H_6 mole fraction, fitting spectra using a standard thermal profile. C_2H_6

auroral data is from our prior work, except for *Voyager* 1 and 2 in 1979. Both *Cassini* and *Voyager* flybys are snapshots of early solar maximum. *Juno* mission will be in 2016–2017, late solar maximum.
Bottom. Auroral intensity (red dots) follow declining sunspot number monthly average since solar maximum ended in about 2001; sunspot number predicted after 2010 by NOAA Space Weather Prediction Center.

These measurements will be the beginning of measurements through the rising Cycle 24 maximum, predicted to be of low intensity and delayed. The continued measurements through the next solar maximum with comparable detail and temporal coverage are necessary to definitively confirm the correlation between solar activity and jovian mid-infrared auroral emission. In comparison, terrestrial auroral activity lags the solar activity peak, suggesting that any relationship between auroral and solar processes will require detailed observation through all phases of the solar cycle to fully describe the phenomenon. If a correlation is confirmed, major revisions will be needed for theories of Jovian aurora.

This work is to provide complementary and temporal information for the context of *Juno* mission, which will launch in 2011 and arrive at Jupiter in 2016, just past the predicted peak of the solar cycle, auroral, temperature, and compositional investigations by the Polar Magnetosphere Suite and the Jupiter Infrared Auroral Mapper, as well as for planning future Jupiter system missions.

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