Loki as observed by the Galileo Near-Infrared Mapping Spectrometer (NIMS)

Ashley Gerard Davies, Rosaly M. C. Lopes-Gautier, William D. Smythe, Robert W. Carlson (JPL/Caltech) and John R. Spencer (Lowell Observatory).

The Galileo spacecraft has been observing Io throughout the Prime and Europa missions. This has allowed the evolution of individual hot spots to be examined. Of all of the many hot spots on Io, Loki has been the most energetic over the last 20 years. It has been observed by NIMS on a number of orbits, with observations including Loki in darkness being collected during orbits G7, C9 and E16. Here, we present preliminary results of analyses of the NIMS night-side and eclipse observations of Loki. The 'best-fit' temperatures given below are +/- 25 K. Areas are +/- 10%. The NIMS G7 observation caught Loki at the peak of a major brightening that began soon after the E6 encounter. A two-temperature fit to the NIMS G7 data produced temperatures and areas of approximately 990 K (covering 3 km2) and 460 K (covering 2320 km2). NIMS observed a less energetic Loki during orbit C9, with temperatures of 962 K (5 km2) and 373 K (11700 km2). The G7-C9 trend might be indicative of a spreading, cooling flow. Loki brightened again in May 1998, and was observed by NIMS in June during the E16 encounter. Temperatures were similar to those obtained during C9, at 345 K (3830 km2) and 612 K (27.4 km2), although the area of the cooler component was very much reduced. The low-temperature component may have been stronger during orbit C9 than E16 in part because the 1997 eruption had been under way for four months by C9, whereas the 1998 eruption had been active for two months by E16. The 3.5 micron brightnesses for these three events are 80 GW/mic/str during G7, 60 GW/mic/str during C9 (both consistant with ground-based observations), and 13 GW/mic/str during E16.

Talk for DPS 31, Padua, Italy, 10-16 October 1999.

Ashley G. Davies

1. Title slide:
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The Galileo spacecraft has been observing Io throughout the Prime and Europa missions. This has allowed the evolution of individual hot spots to be examined. Last year we talked about the evolution of Pele and Pillan Patera. This year we will show the results of analysis of observations of Loki with the Near Infrared Mapping spectrometer (NIMS) on Galileo. The 'best-fit' temperatures given today are +/- 25 K, and area uncertainties are +/- 10%.

2. Slide: Loki Patera

Of all of the many hot spots on Io, Loki has been the most energetic over the last 20 years. It has been observed by NIMS on a number of orbits, with observations including Loki in darkness being collected during orbits G7, C9, E16 and C22. C22 data is currently being evaluated. This image shows four views of Loki: upper left is the Voyager 1 hi-res image; upper right, Voyager colour; bottom right, Voyager 2; bottom left, Galileo G1 (June 1996).

3. Slides: NIMS G7 observation of Loki
4. Slides: NIMS E6 and G7 comparison at 2.95 microns

NIMS observed Loki during orbit G7 on 12 April 1997, at a range of 556,000 km, with Loki positioned in darkness. Here is the NIMS G7 Loki spectrum. Unfortunately, the middle detector range saturated out, but we still have enough usable data. Intensities from adjacent pixels have been added to account for the instrument point spread function. The full spectrum is divided up into individual grating position spectra each of which is fitted in turn. At the time of the observation, Loki was at the peak of a major brightening that began soon after the E6 encounter, observed by ground-based observers on March 12th 1997 from the IRTF.

5. Slide: Loki G7 2-temp fit.

Here is a two-temperature fit to the G7 data. We get temperatures and areas of approximately 990 K, with an area of approximately 3 km2, and 460 K covering an area of approximately 2320 km2. Areas have been corrected for emergence angle.

6. Slide: C9inchemis06 observation (this is a 35 mm slide).
7. Slide: C9 Loki 2T fit

Loki was observed again in orbit C9: the C9 observation also contains Pele and Pillan Patera. The other slide shows the Loki spectrum and a two component fit. By C9, June 1997, the Loki eruption had died down considerably: at least, at NIMS wavelengths, Loki was less energetic, with temperatures of 962 K, covering 5 km2, and 373 K covering 11,700 km2. The G7-C9 trend might be indicative of a spreading, cooling flow.

8. Slide: E16 loki observation and 2T fit.

Loki brightened again in
May 1998, and was observed by NIMS in June during the E16 encounter. Temperatures were similar to those obtained during C9, at 345 K (3830 km2) and 612 K (27.4 km2), although the area of the cooler component was very much

reduced. The low-temperature component may have been stronger during orbit C9 than E16 in part because the 1997 eruption had been under way for four months by C9, whereas the 1998 eruption had been active for two months by E16.

9. Evolution of 3.5 micron brightness at Loki.

This slide shows the trend of emission from Loki (after Lopes-Gautier, Icarus, 1999). The 3.5 micron brightnesses for these three events are shown here, having been converted from NIMS intensity units to GW/str/micron for comparison with ground-based observations. The calculated NIMS 3.5 micron brightnesses are 80 GW/mic/str during G7, 60 GW/mic/str during C9 (both consistant with ground-based observations), and 13 GW/mic/str during E16.

10. Conclusion.
To summarise:

1. NIMS has been observing Loki intermittantly during the Galileo Prime and Europa missions.

2. It has been possible to observe thermal outbursts from Loki and chart the subsequent evolution of the eruptions.

3. The development of algorithms to separate thermal from reflected signals in dayside observations will lead to more data points on the evolution time-line.

4. NIMS data agree very closely with data collected from ground-based instruments

5. Application of more sophisticated silicate cooling models, and comparison with SSI data and instruments sensitive at longer wavelengths will lead to better understanding of magma temperatures, eruption style, and rates of emplacement of material at Loki.

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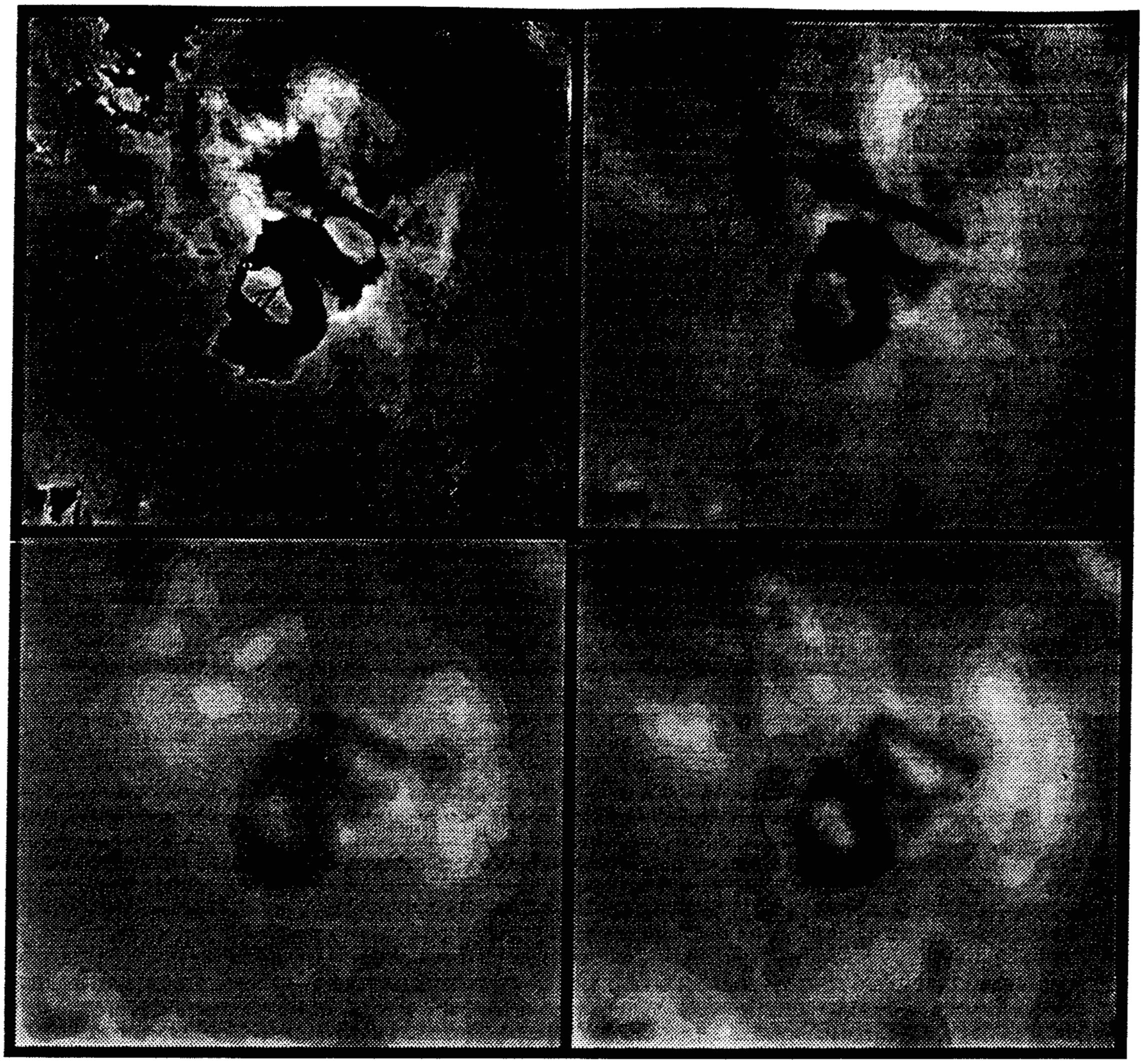
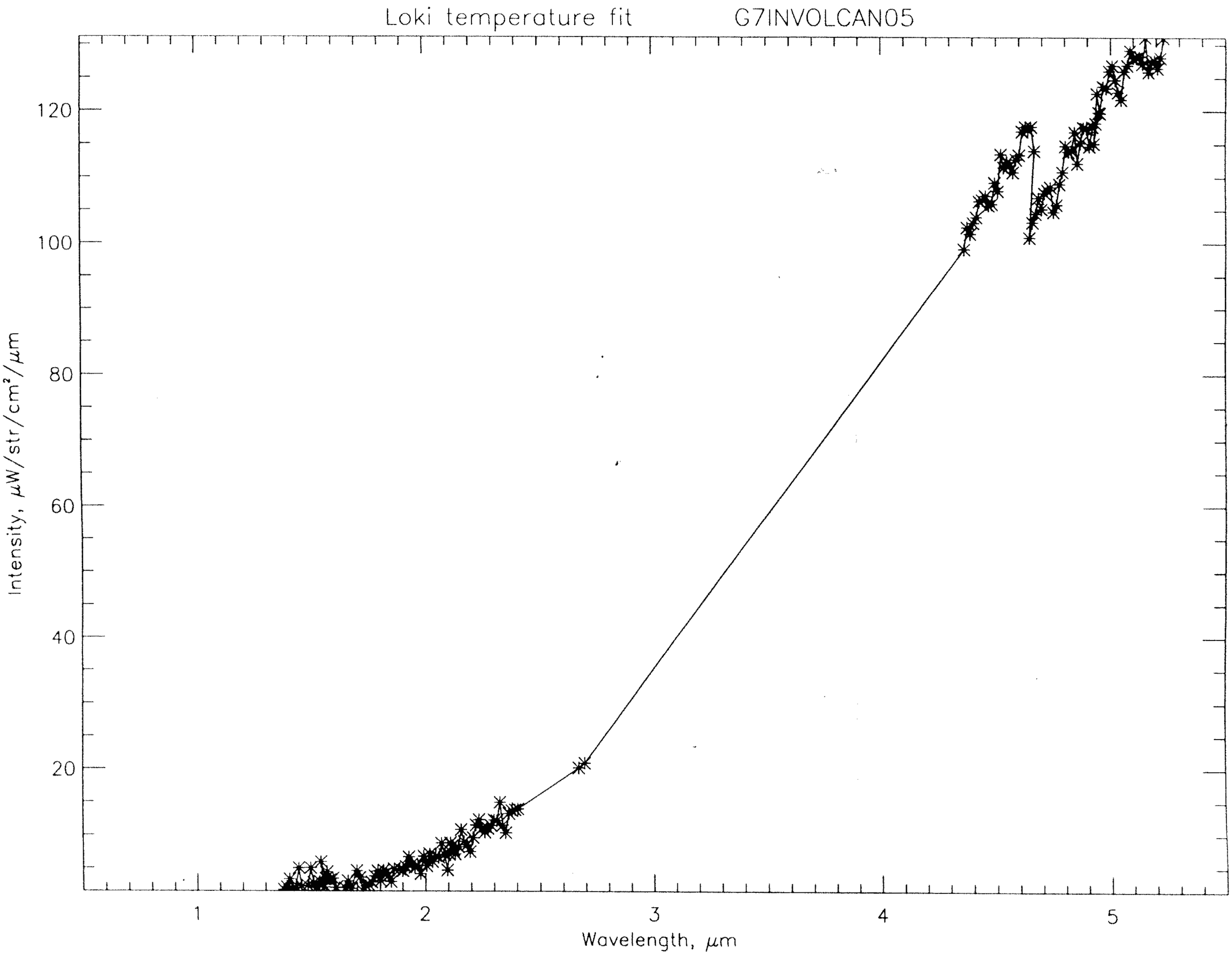
DPS 31, Padova, Italy
October 15th 1999

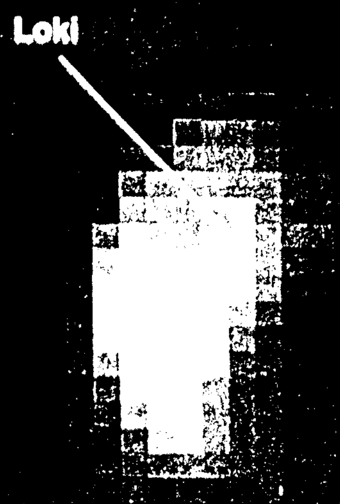


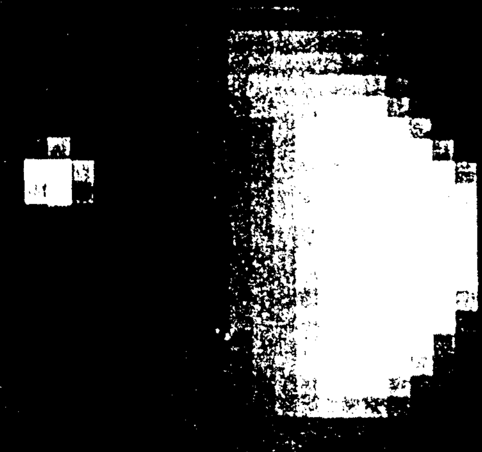


Loki temperature fit G7INVOLCAN05
Intensity, μW/str/cm²/μm
Wavelength, μm
120
100
80
60
40
20
1
2
3
4
5

3

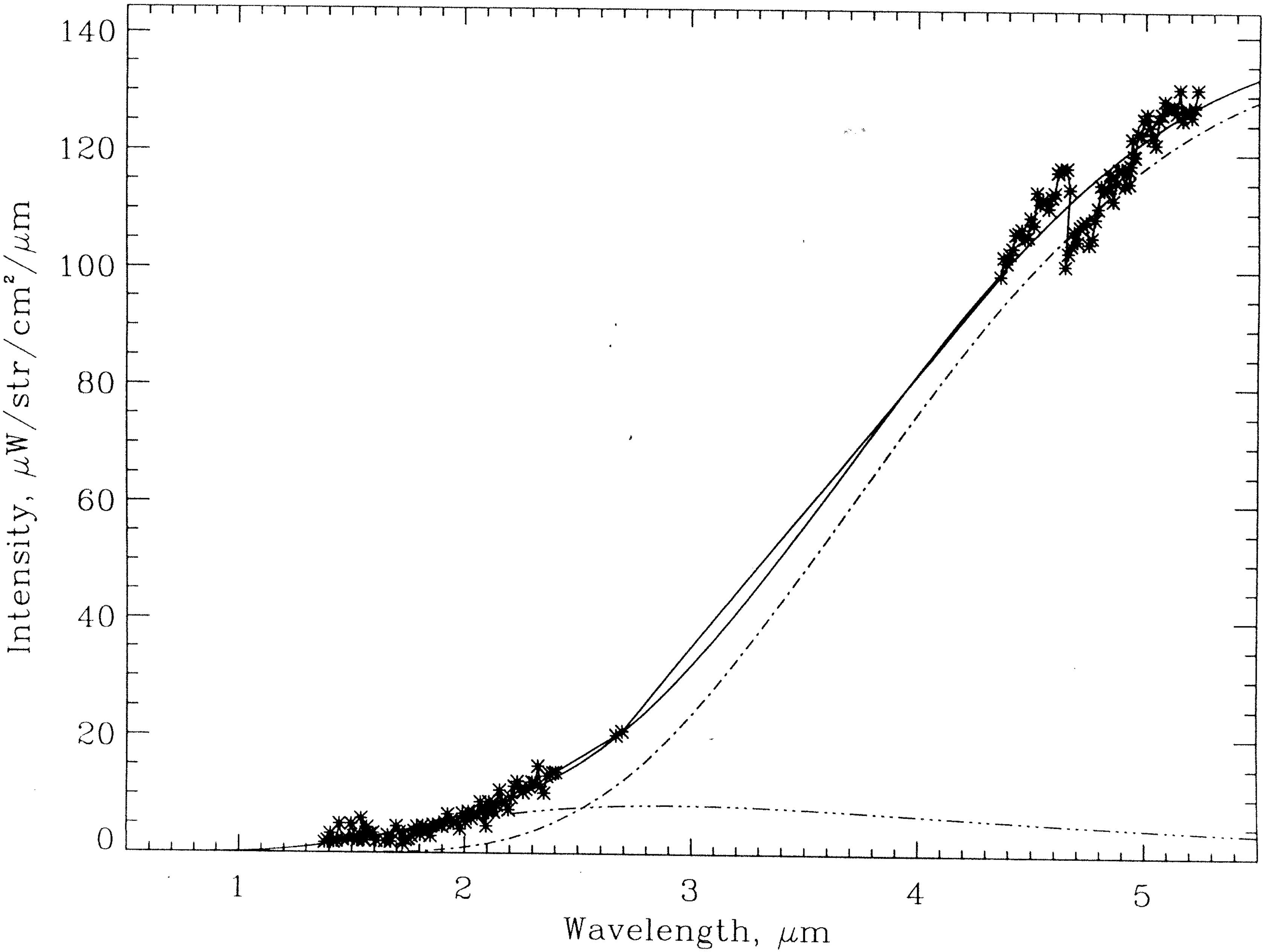
LOKI BRIGHTENING BETWEEN ORBITS E6 AND G7





E6INCHEMIS06
230W-360W 351 km / NIMS pixel
Feb. 21, 1997 UTC=3:57:33
2.9564 microns

G7INCHEMIS05
184W-345W 300 km / NIMS pixel
Apr. 4, 1997 UTC=4:49:41
2.9564 microns



5

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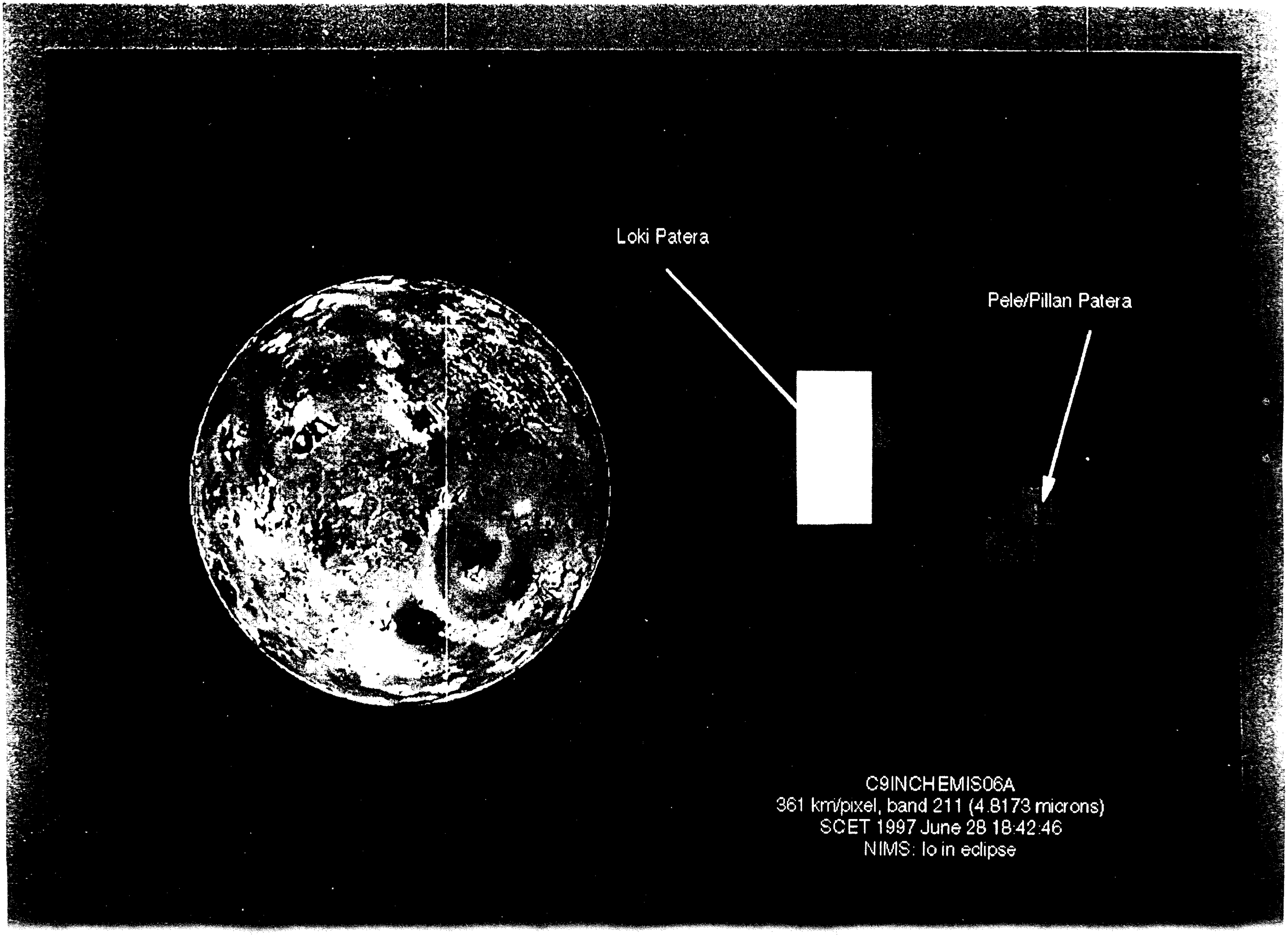
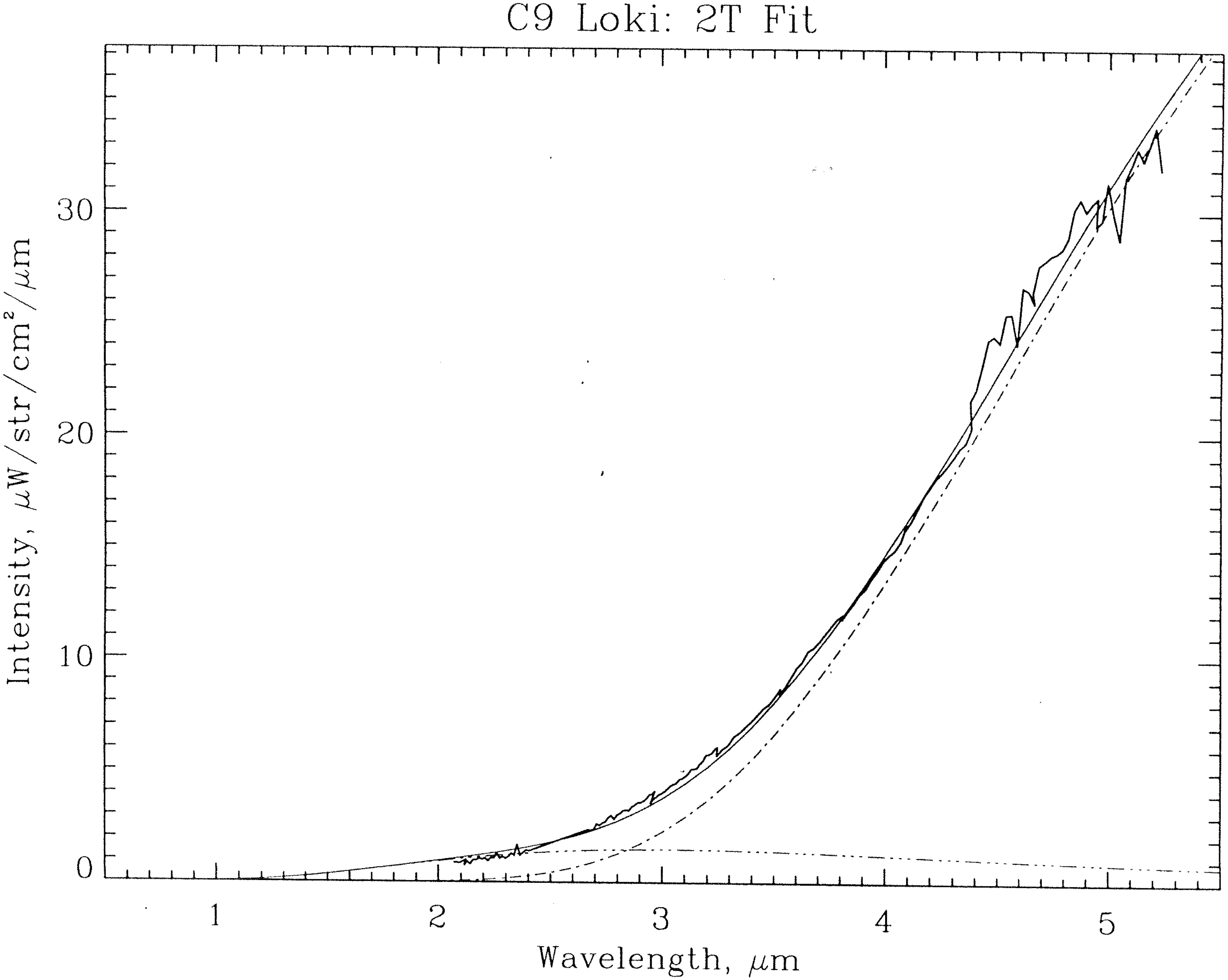
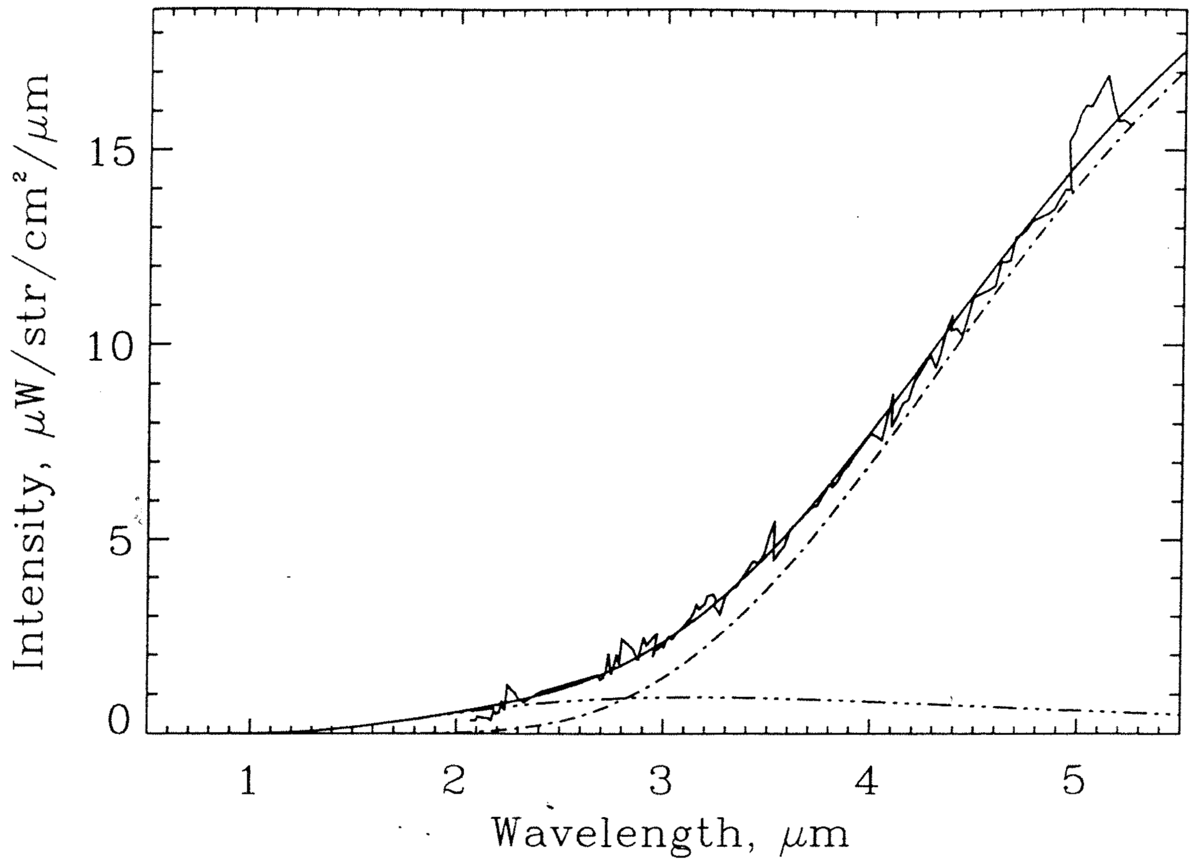
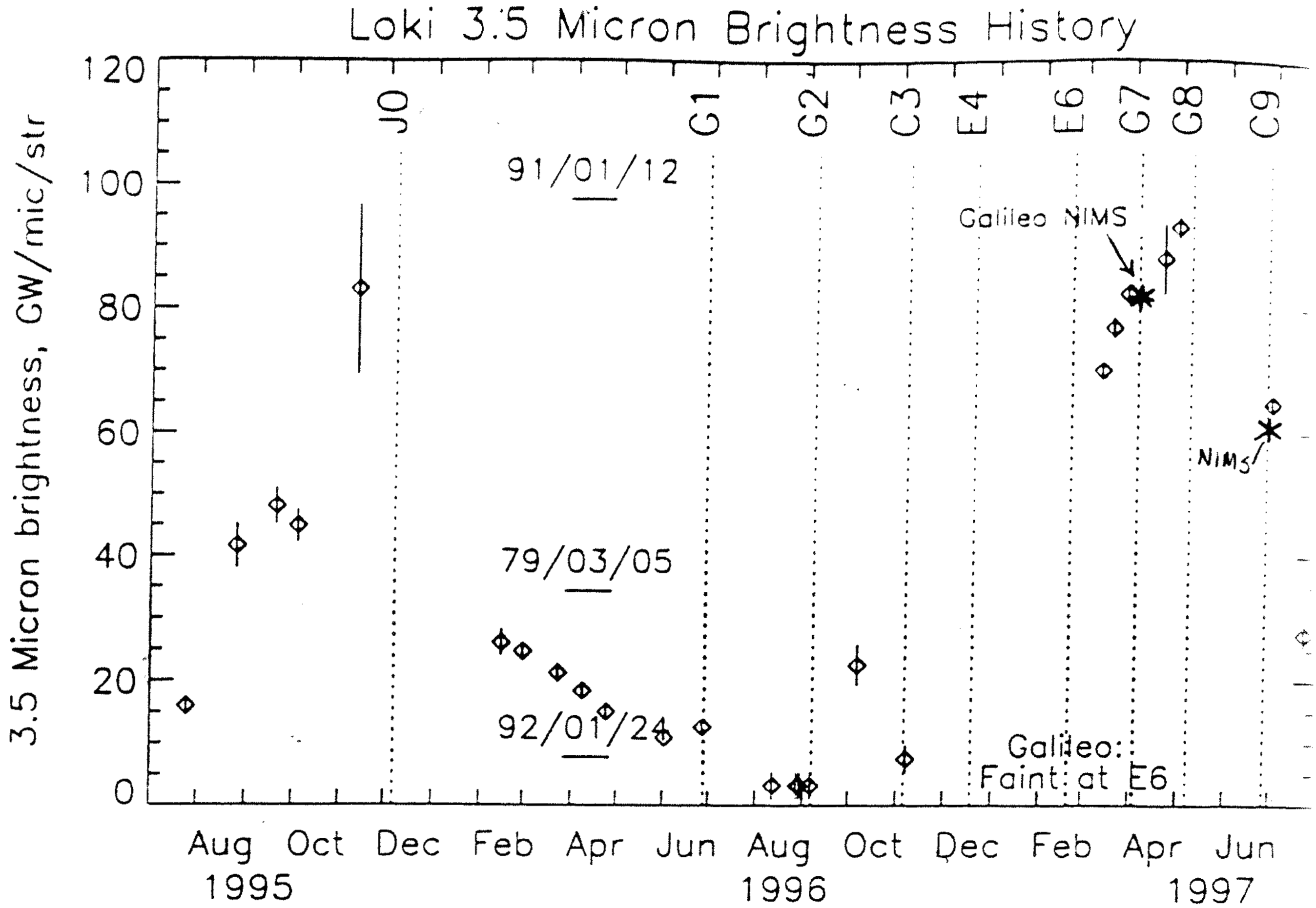

Loki Patera
Pele/Pillan Patera
C9INCHEMIS06A
361 km/pixel, band 211 (4.8173 microns)
SCET 1997 June 28 18:42:46
NIMS: Io in eclipse


C9 Loki: 2T Fit
Intensity, μW/str/cm^2/μm
0
10
20
30
1
2
3
4
5
Wavelength, μm

E16 2T fit to Loki data




Loki 3.5 Micron Brightness History
3.5 Micron brightness, GW/mic/str
120
100
80
60
40
20
0
J0
G1
G2
C3
E4
E6
G7
G8
C9
91/01/12
79/03/05
92/01/24
Galileo NIMS
NIMS
Galileo:
Faint at E6
Aug
Oct
Dec
Feb
Apr
Jun
Aug
Oct
Dec
Feb
Apr
Jun
1995
1996
1997

Summary

1. NIMS has been observing Loki intermittantly during the Galileo Prime and Europa missions

2. NIMS has observed thermal outbursts from Loki, and has charted the subsequent evolution of these eruptions

3. The application of algorithms to separate thermal signal from reflected sunlight in dayside observations of Io will lead to more data points on the evolutionary time-line for Loki and other volcanoes

4. NIMS-derived 3.5 micron brightness agree very closely with data collected by ground-based instruments

5. Application of sophisticated silicate cooling models, in conjunction with data collected from SSI (especially the C9 data), and other instruments at longer wavelengths, will lead to better constraints on magma temperature, eruption style, and rate of emplacement of material.