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Io's Loki volcano: An explanation of its tricky behaviour and prediction for the next eruption

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Abstract

Loki is Io's largest, most powerful, and best-studied active volcano. When erupting, it accounts for nearly 15% of the total heat output from Io [1]. It is generally bright enough that it can easily be observed using ground-based telescopes, and its brightness has been measured hundreds of times over the past 30 years [2-6]. Early work based on both spacecraft and ground based data determined that Loki erupted periodically and suggested that Loki is a large overturning lava lake [2]. More recent work has built on that original model [3, 7-9]. Our collection of all available data from 1998 – 2018 includes more than 300 data points from 3 different telescopes over 30 years (figure 1).

1. Periodic Eruptions

From 1988 through 2000, Loki erupted periodically approximately every 540 days [2]. For approximately 230 of those days, Loki was bright, indicating an eruption, while the rest of the time, Loki was substantially dimmer, by nearly an order of magnitude, indicating a quiescent period. For the subsequent decade, observations were obtained les frequently and there is no clear periodicity to any eruptions. Beginning in 2013, Loki brightnesses were again consistent with periodic eruptions, with a shorter period of ~475 days and approximately 160-day long eruptions (figure 2).

2. Prediction for next eruption

In our 2018 LPSC abstract, we predicted that the next Loki eruption would be in May 2018 [10]. When observations were obtained, we found that the eruption began between May 23, 2018 when Loki's brightness was 13 GW/micron/str and June 6 when it was 29 GW/micron/str. By July 31 the brightness had grown to 96 GW/micon/str. The 2017 and 2018 eruptions have well defined start dates that are 440 +/- 10 days apart. **If the next eruption maintains the 475 day period, it will begin in September of 2019. If it waits only 440 days, it will start in late July**.

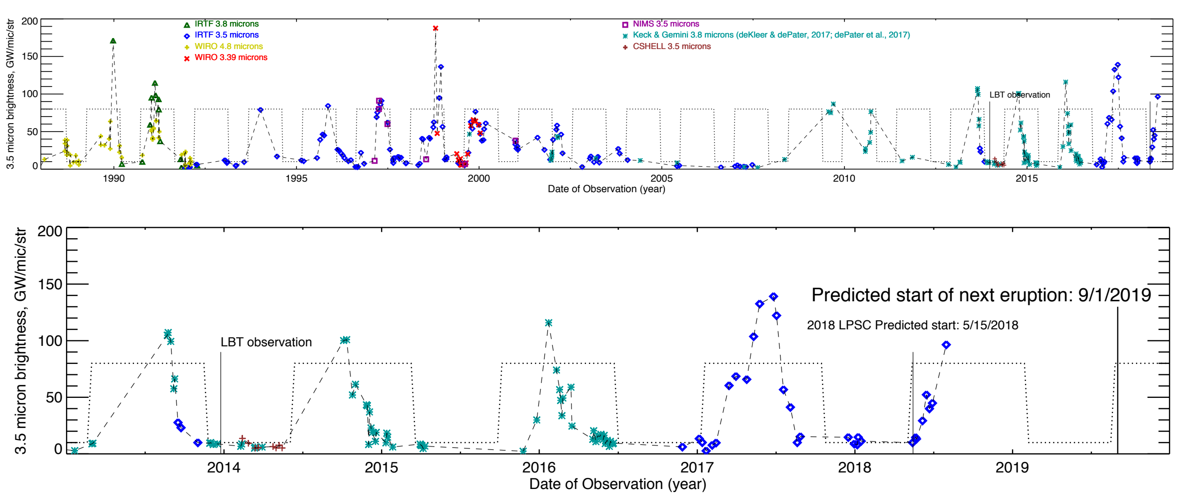

Figure 1: The brightness of Loki as a function of time from various sources. The upper panel shows the total available time history while the bottom is only the past 6 years. The square wave in the background of the top panel is the original 540-day period while the bottom panel shows the newer 475-day period..

3. Model Results

The model of Loki as an overturning lava lake gives a relationship between the duration and average brightness of an eruption [3]. Five eruptions between 1988 and 2000 were observed often enough to have well defined start and end dates [3] while only two of the most recent observations do (figure 3). The more recent observations have a higher average brightness, which can be seen in figure 1, consistent with their shorter average duration. In the model, this increase in brightness is due to a larger area of the lava lake being revealed at any time, which, of course, results in a shorter total time to resurface the entire lava lake.

In our model [3], Loki is a lava lake with a crust that solidifies as it cools. The amount of time between eruptions is the amount of time necessary for the crust to become gravitationally unstable and is, therefore, related to the porosity of the lava [2-3]. A shorter time between eruptions suggests a slightly smaller density and, thus, a larger porosity.

4. Location of Eruptions

The brightest part of Loki varies [5]. During a brightening, the location lies within the dark part of the Patera floor while between brightenings, the location generally lies within the bright "island" at the centre of Loki Patera. The locations during the most recent brightenings also suggest that the direction of overturn may have changed {5, 7].

5. Possible explanation

Could an influx of fresh magma into the lake explain both the inferred change in direction and the change in porosity that controls the difference in periodicity? An increase in the average porosity of the magma is consistent with decrease in Loki's periodicity.

References

[1] Spencer J. R., et al. (2000) *Science, 288,* 1198-1201.

[2] Rathbun, J. A. et al. (2002) *Geophys. Res. Lett., 29(10*), doi:10.1029/2002GL014747.

[3] Rathbun, J. A. and Spencer, J. R. (2006) *Geophys. Res. Lett., 33*, doi:10.1029/2006GL026844.

[4] Rathbun, J. A. and Spencer, J. R. (2010) *Icarus, 209,* 625-630.

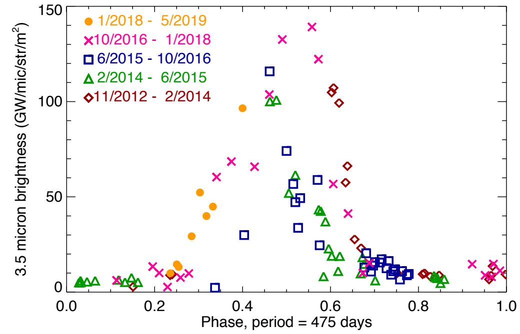

Figure 2: Most recent data from figure 1 wrapped to the proposed 475-day period.

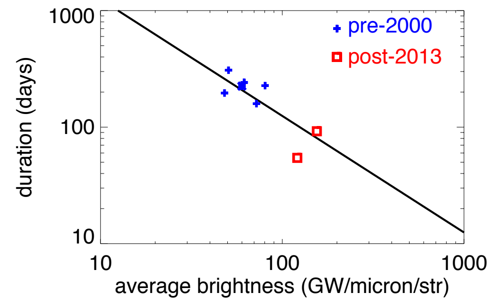

Figure 3: The average duration of and brightness during several eruption events with well-constrained start and end dates. The solid line is a prediction based on the model of Loki as an overturning lava lake [3]. The plus signs are eruptions pre-2000 with the asterisk as the average of those points. The squares are the 2 most recent eruptions.

[5] de Kleer, K and de Pater, I. (2017) *Icarus, 289*, 181-198.

[6] de Pater, I., et al., (2017) *Icarus, 297*, 265-281.

[7] de Kleer, K., et al. (2017) *Nature Lett., 545*, 199-202.

[8] Davies, A. G. (2003) *Geophys. Res. Lett.,* 30(21), doi:10.1029/2003GL018371 .

[9] Matson, D. L., et al. (2006) *J. Geophys. Res., 111*, doi:10.1029/2006JE002703.

[10] Rathbun, J. A. et al. (2018) *LPSC 49*, abs. no. 2208.