The origin of the second largest satellite of Neptune, Nereid, is still unclear. We performed photometric observations for Nereid to measure its rotation properties using Subaru/S-Cam. The obtained lightcurves show a rapid rotation with a period of 11.5 hr. We suggest that Nereid formed an external region and later was captured into the current orbit by Neptune.

### Observations
- **Date:** Sep 1, 2, and 29, 2008
- **Subaru telescope + Suprime-Cam**
- **240-sec exposure with VR-band**
- **About 20 sequential shots in 2 hr**
- **Relative photometry using 10 stars with \( V - R \approx 0.44 \text{ mag} \)**
- **Very low photometric uncertainty of \( \sim 0.002 \text{ mag} \)**

### Lightcurves
- **Rotation period:** \( 11.5 \pm 0.1 \text{ hr} \)
- **Peak-to-peak amplitude:** \( 0.031 \pm 0.001 \text{ mag} \)

- **Consistent with Grav+ (2005)**
- **Rapid, constant rotation (unlikely in resonance/chaos)**

### Discussion

#### Two scenarios for Nereid’s origin:

**I. Formed in the circumplanetary disk**
- Synchronous rotation due to tidal locking
  - Initial semi-major axis \( \sim 2.7 \, R_{\text{Nep}} \) (currently at \( 224 \, R_{\text{Nep}} \))
  - Disagrees with orbit–mass relation of regular satellites
- Located at \( 4.4 \, R_{\text{Nep}} \) (agrees with the relation)
- Required an impact of a body with \( \sim 60 \text{ km in diameter} \)

**II. Captured body from a heliocentric orbit**
- The rotation state is usual for an irregular satellite
- Consistent with the size-spin relation of TNOs/Centaurs

**Conclusion:** Nereid has been an irregular satellite since it began to orbit around Neptune.