Venus in false color (R 2020 nm, G 283 nm, B 365 nm)
https://t.co/OuaBrWfI98

Brightness modulations of our nearest terrestrial planet Venus reveal atmospheric super-rotation rather than surface features

Y. J. Lee[1], A. García Muñoz[1], T. Imamura[2], M. Yamada[3], T. Satoh[4], A. Yamazaki[4], S. Watanabe[5]
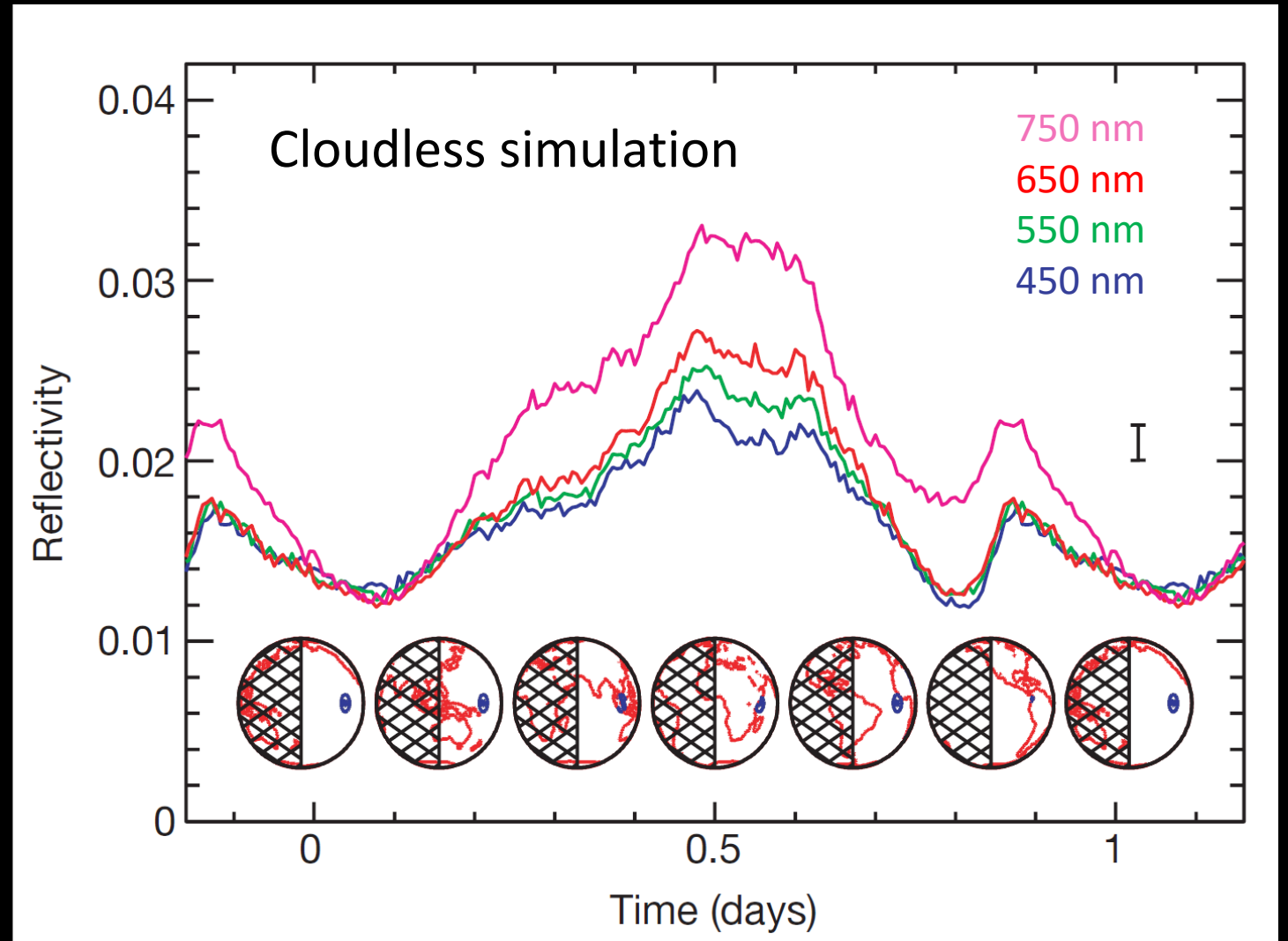
1. TU Berlin, Germany, 2. Univ. of Tokyo, Japan, 3. PERC, Japan, 4. ISAS/JAXA, Japan, 5. Hokkaido Inf. Univ. Japan

Brightness modulations of the Earth

Light curve modulation
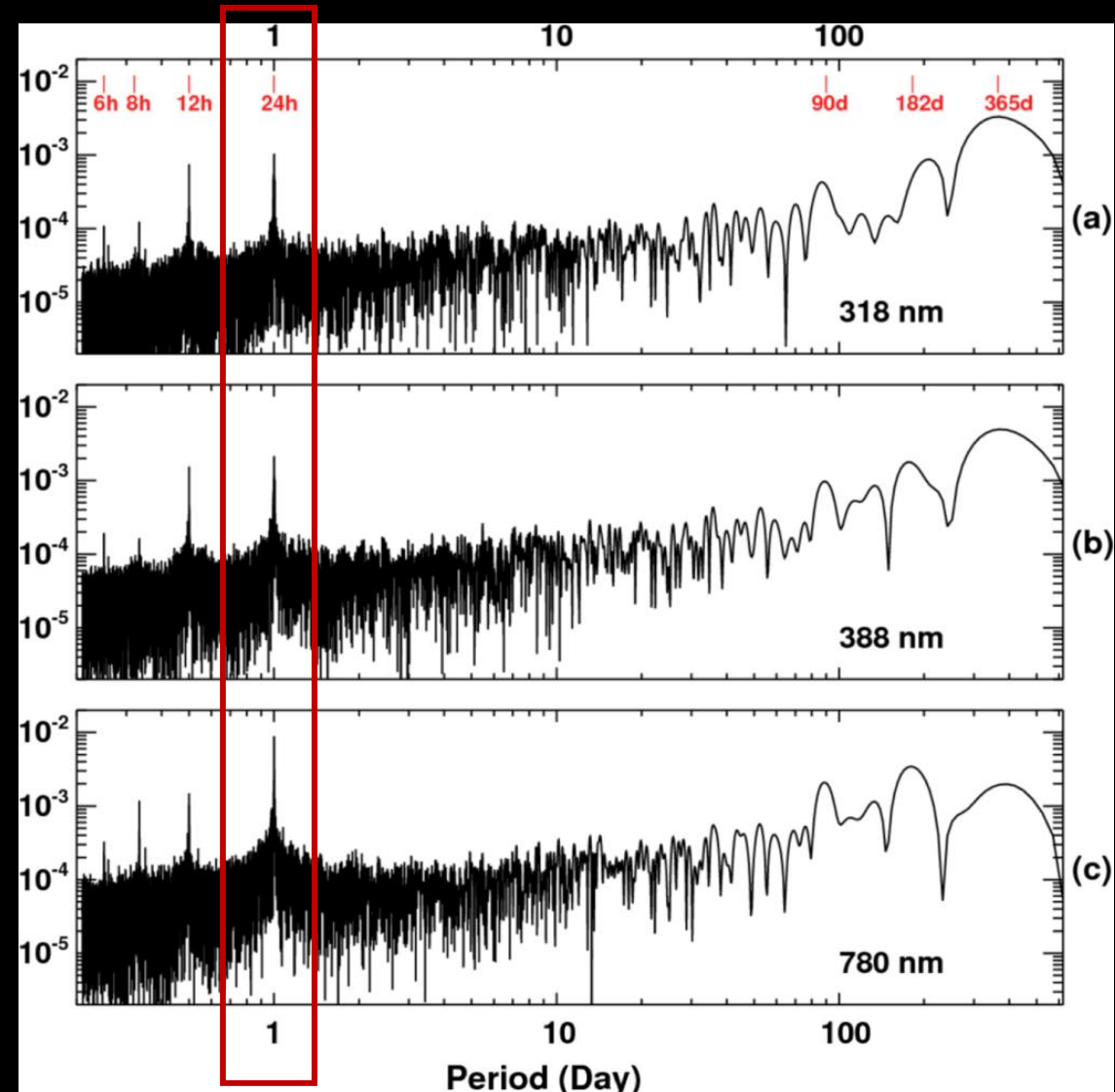→ Rotation rate

[Ford et al. 2001]

Brightness modulations of the Earth

DISCOVR observations (L$_1$)
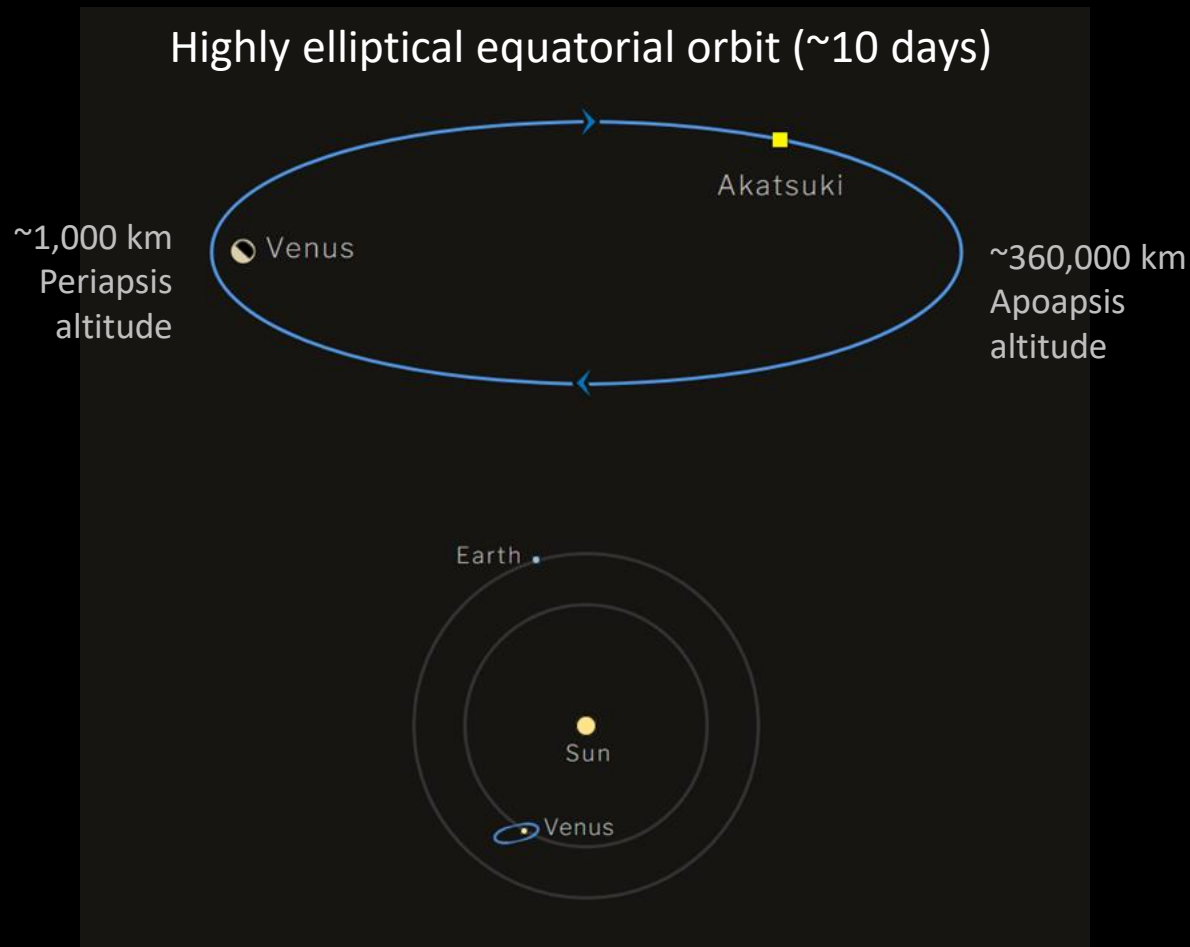over 2 years
at multi-wavelengths
→ 24 h peak

[Jiang et al. 2018]
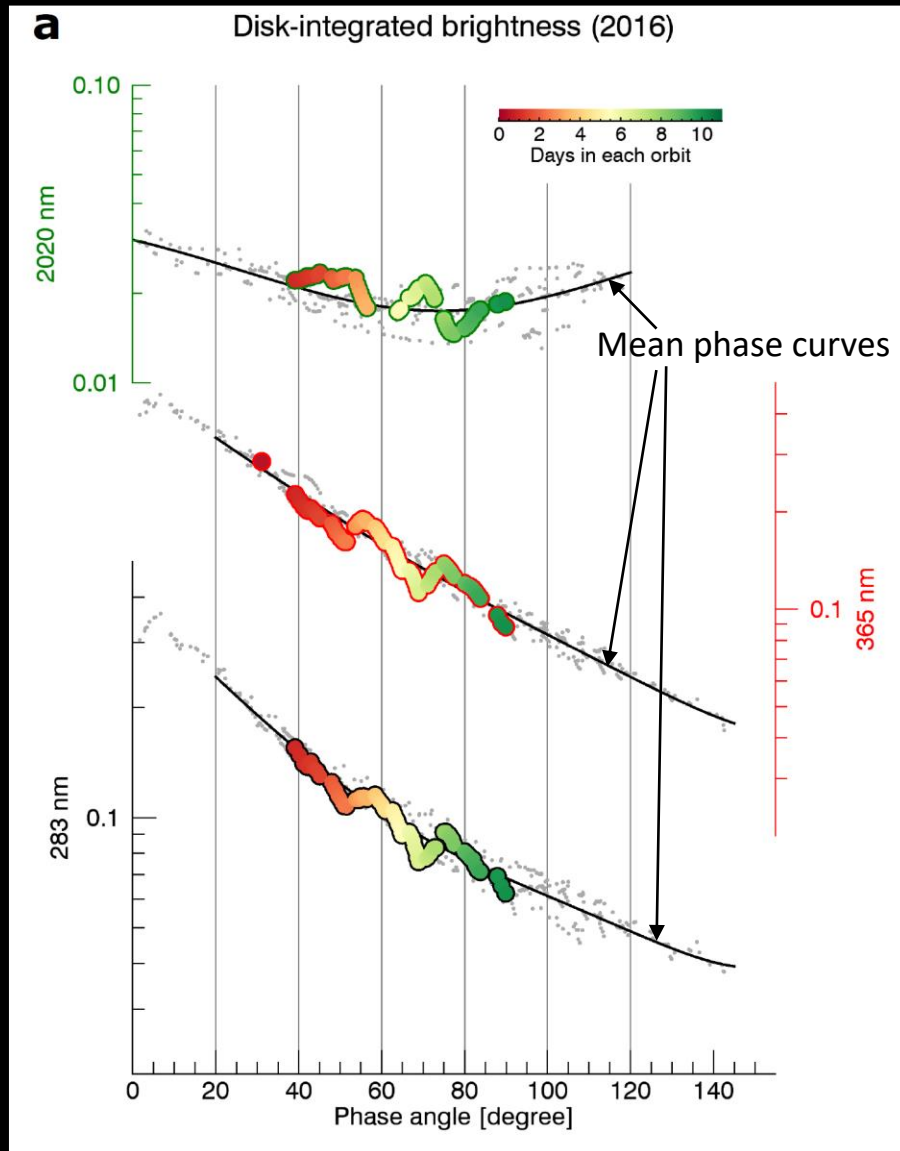
Towards future direct-imaging

Venus as an exoplanet:
Venus' thick cloudy atmosphere

Highly elliptical equatorial orbit (~10 days)

Akatsuki

Venus

~1,000 km Periapsis altitude

~360,000 km Apoapsis altitude

Earth

Sun

Venus

https://akatsuki.isas.jaxa.jp/en/gallery/orbit/

- JAXA's Venus orbiter Akatsuki (Dec 2015-current)

- Reflected solar light at
  - 283 and 365 nm (Dec 2015- Jan 2019) → SO_2 and unknown absorber
  - 2020 nm (2016) → CO_2

- 2 hrs. interval global imaging

- The solar phase angle changes with time

Observed Venus' disk-integrated brightness

a

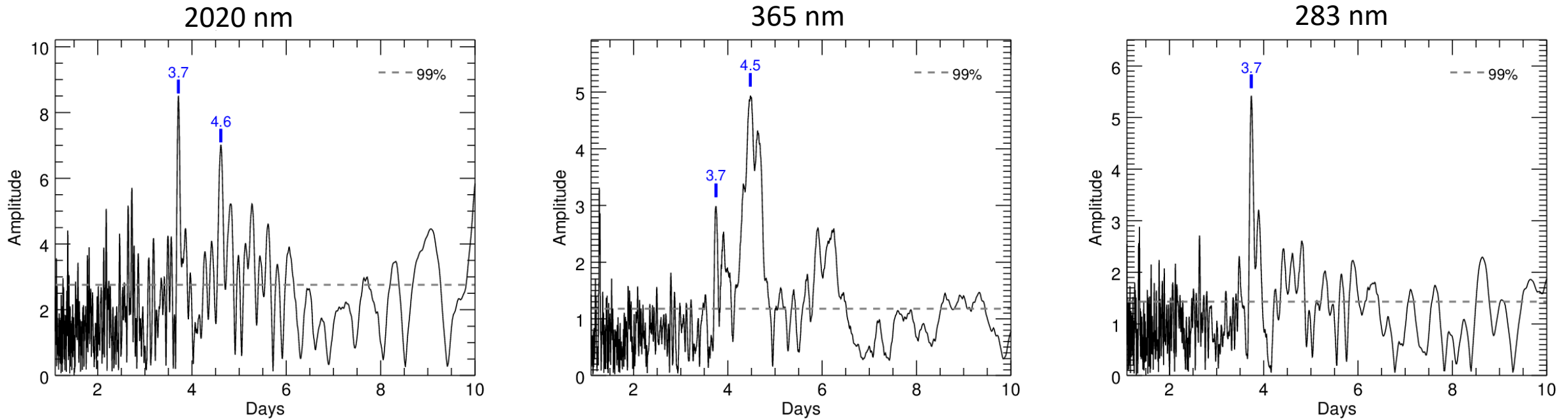Disk-integrated brightness (2016)

Mean phase curves

← *Supplementary Movie 1 (Lee et al. 2020): Temporal variations*
https://static-content.springer.com/esm/art%3A10.1038%2Fs41467-020-19385-6/MediaObjects/41467_2020_19385_MOESM4_ESM.mp4

- Clear temporal variations of brightness
  → Atmospheric super-rotation (~4 days)
  rather than the surface rotation (243 days)

- Wavelength dependency:
  opposite signs of fluctuations
  between UV and NIR
  → Atmospheric absorption

[Lee et al. 2020]

Periodicity analysis of Venus' brightness

- **Two periods at 3.7 and 4.5-4.6 days**
  → Global scale atmospheric waves, Rossby and Kelvin waves, which are temporally variable
- Wavelength dependency:
  a single peak at 283 nm
  → Atmospheric phenomena, depending on absorbing agent's distribution

[Lee et al. 2020]

Caution on possible Venus-like
thick cloudy atmospheres

- A false positive of the surface rotation detection
  → Long-term and multispectral observations can be used to identify the existence of an atmosphere

- Future direct-imaging of LUVOIR and HabEx

- For more details,
  see our paper at Nature Communications (Nov 2020)
  https://doi.org/10.1038/s41467-020-19385-6

Yeon Joo Lee (y.j.lee@astro.physik.tu-berlin.de)