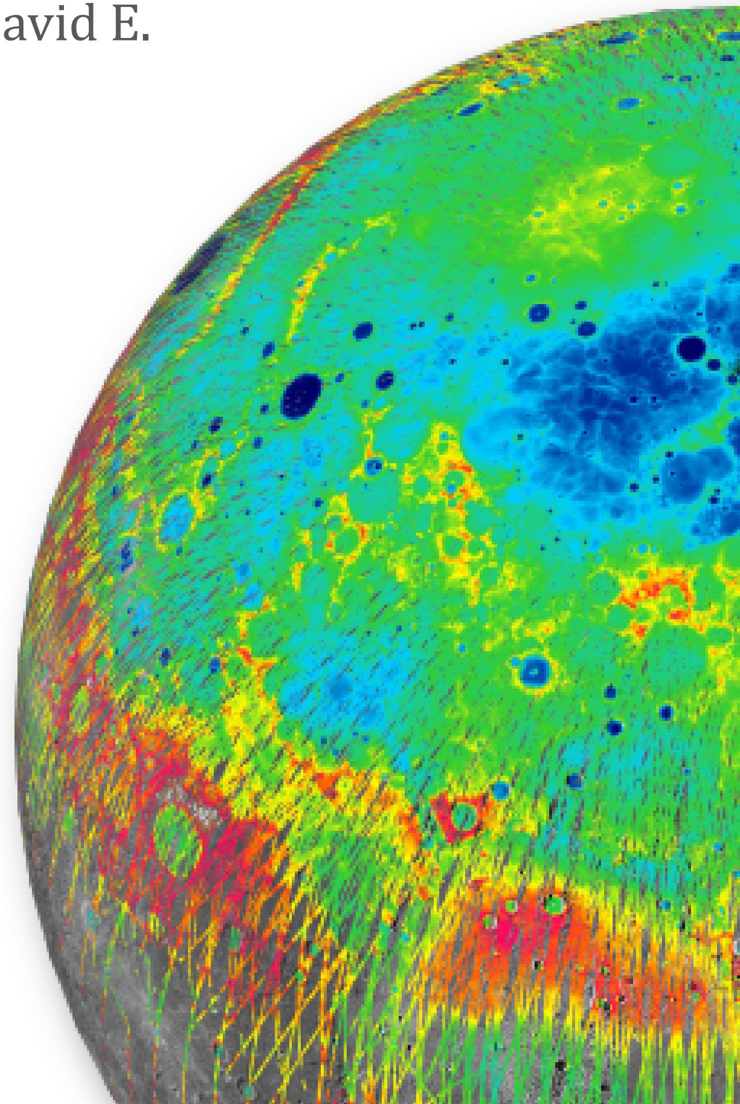
Mercury's rotational state from combined MESSENGER laser altimeter and image data

Alexander Stark, Jürgen Oberst, Frank Preusker, Jean-Luc Margot, Roger J. Phillips, Gregory A. Neumann, David E. Smith, Maria T. Zuber, and Sean C. Solomon

- MESSENGER data
- Co-registration Method
- Mercury's rotational parameters
- Implications on Mercury's interior



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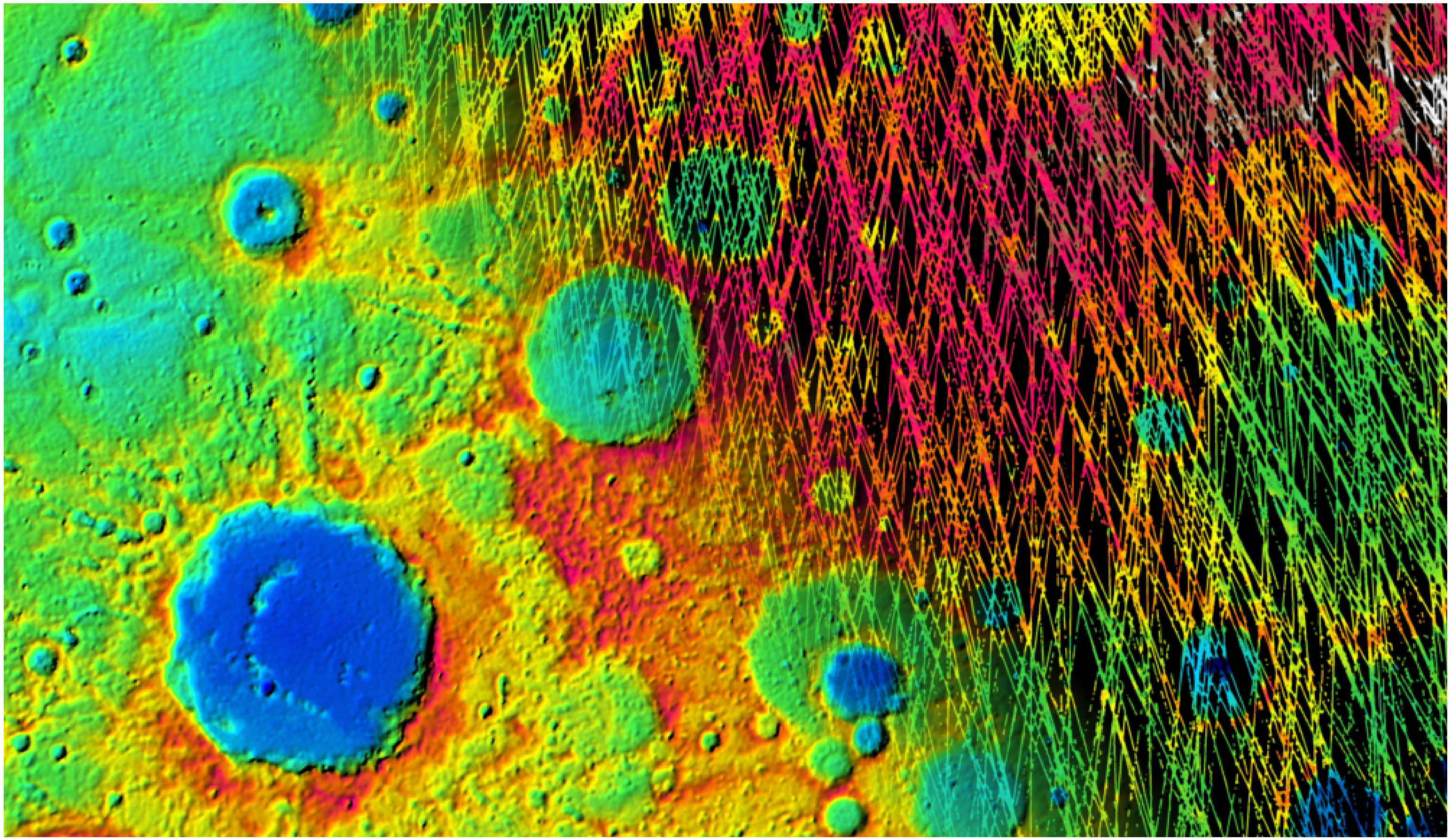
Measurement of Mercury's rotation

Co – registration method

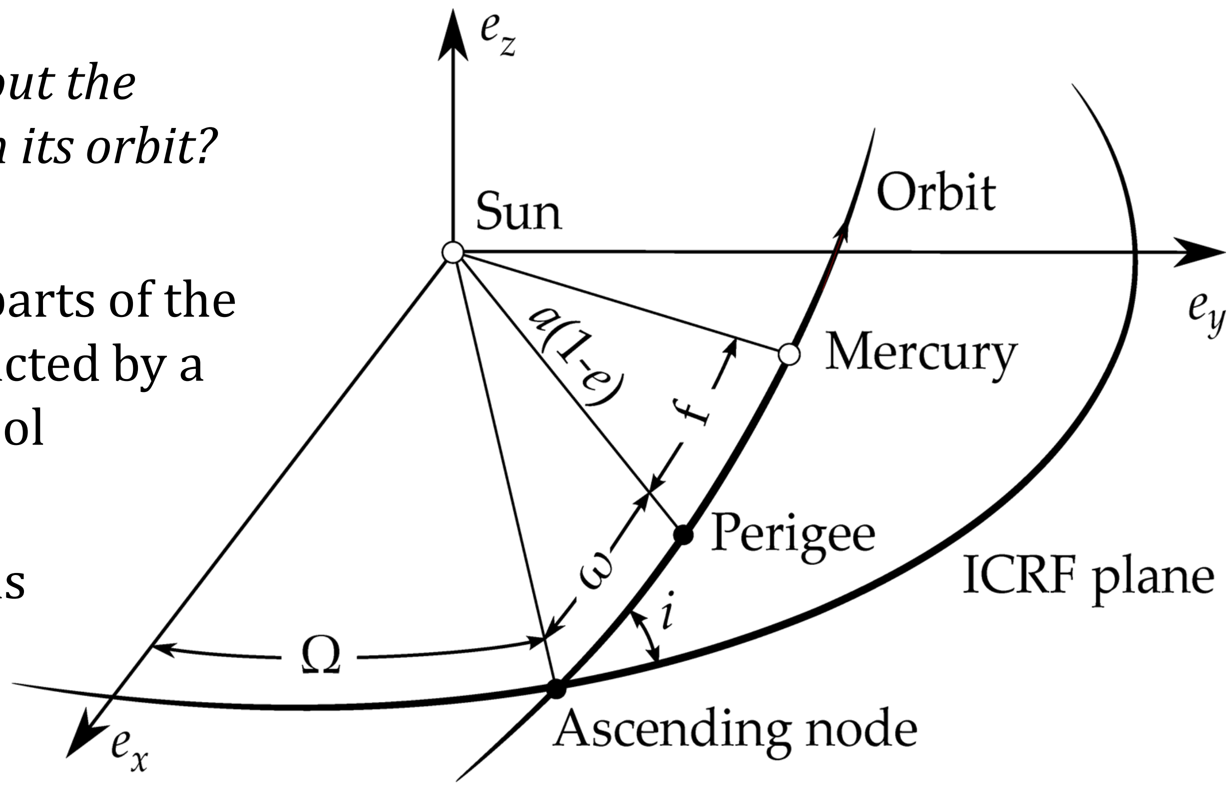
- laser altimeter profiles and digital terrains models derived from stereophotogrammetry (stereo DTMs) form complementary data sets



Mercury's resonant rotation model

Spin-orbit coupling

What can we predict about the rotation of Mercury from its orbit?



- secular and periodic parts of the orbital elements extracted by a frequency mapping tool
- most recent ephemeris of Mercury with MESSENGER data

$$x(t) = \underbrace{\boldsymbol{x_0} + \boldsymbol{x_1} t + \boldsymbol{x_2} t^2}_{\text{secular part}} + \underbrace{\sum_i A_i \cos(\nu_i t + \phi_i)}_{\text{periodic part}} \quad \text{with } x \in \{a, e, I, \Omega, \omega, M\}$$

Measurement of Mercury's rotation

Results – Rotational parameters

rotational parameter	literature value	**resonant rotation** [c]	**measured** [d] **(this work)**
rotation rate	6.1385025 °/day [a]	$\mathbf{6.1385068\ °/day}$	$\mathbf{6.13851804°/day}$
obliquity	$2.04 \pm 0.08'$ [b]	-	$\mathbf{2.029 \pm 0.085'}$
libration amplitude	$38.5 \pm 1.6''$ [b]	-	$\mathbf{38.9 \pm 1.3''}$

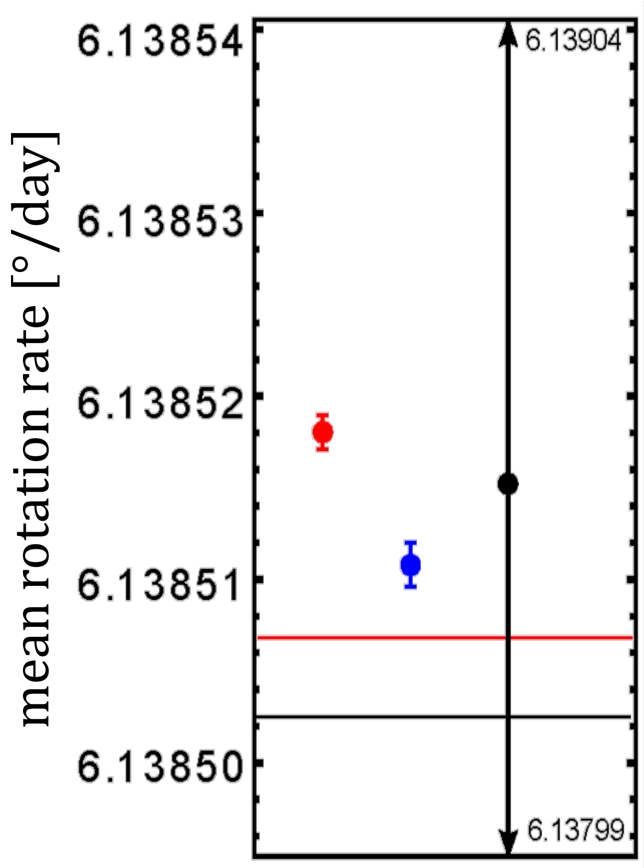
→ Earth-based observations of Mercury's rotation (Margot et al., 2012) could be confirmed!

[a] Archinal et al., IAU report, Celest. Mech. Dyn. Astron. 109, 2011)
[b] Margot et al., JGR Planets 117, E00L09, 2012
[c] Stark et al., Celest. Mech. Dyn. Astron. 123, 2015.
[d] Stark et al., Geophys. Res. Planets 42, 2015.

Measurement of Mercury's rotation

Results – Rotation rate

→ Mercury rotates faster than expected!



possible explanation:

- Mercury performs a long-period libration (about 12 years) caused by perturbations by Jupiter on Mercury's orbit

Stark et al., Geophys. Res. Planets 42, 2015

Klaasen , Icarus 28, 1976

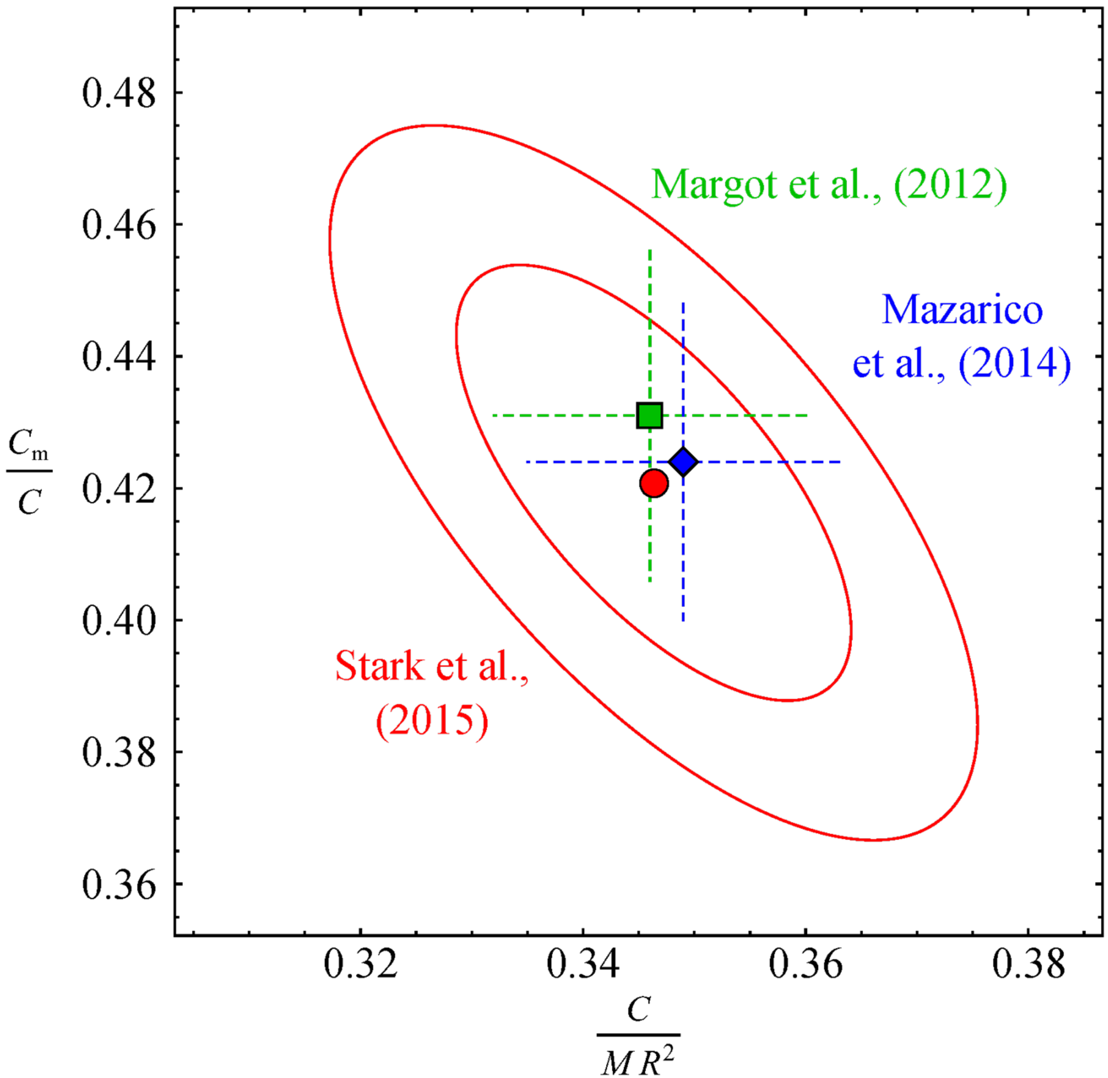
Mazarico et al., J. Geophys. Res. Planets 119, 2014

Stark et al., Celest. Mech. Dyn. Astron. 123, 2015

Archinal et al., Celest. Mech. Dyn. Astron. 109, 2011

Implications on Mercury's interior

Moments of inertia



Propagation of the covariance of rotational parameters and gravity coefficients to the covariance of moment of inertia ratios (via Monte Carlo)

$$\frac{B-A}{C_m} = (2.206 \pm 0.074\,) \times 10^{-4}$$

$$\frac{C}{MR^2} = 0.346 \pm 0.011$$

$$\frac{C_m}{MR^2} = 0.1458 \pm 0.0049$$

$$\frac{C_m}{C} = 0.421 \pm 0.021$$

More details: PhD thesis by A. Stark

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