

DR. VISHNU VISWANATHAN

Center for Space Sciences and Technology, University of Maryland, Baltimore County (UMBC)
 Planetary Geology, Geophys. and Geochem. Lab, NASA Goddard Space Flight Center (GSFC)
 Bldg. 34, S296A, 8800 Greenbelt Rd., Greenbelt, MD, 20771, United States
 Email: vishnu.viswanathan@nasa.gov, Tel: +1 301-614-6466, Mob: +1 202-876-6449

PROFESSIONAL BACKGROUND

Dr. Vishnu Viswanathan's research is focused on the analysis of tracking data such as radio, laser and images, to determine the geophysical, orbital, and rotational properties of planetary bodies. In 2017, Dr. Viswanathan improved the orbital-rotational dynamical model of the Moon and fitted it to over five decades of lunar laser ranging (LLR) data with gravity field constraints from the NASA GRAIL mission. This model is one of the three primary references in the world that provides high-precision planetary and lunar ephemerides. In 2018, Dr. Viswanathan used this model to perform a fundamental physics test of the universality of free fall using the Earth-Moon system as test bodies, improving upon previous constraints on the principle of equivalence. In 2019, Dr. Viswanathan further expanded the capabilities of this model which resulted in the strongest constraint known for the shape and size of the lunar core-mantle boundary. In 2020, Dr. Viswanathan published two white papers submitted to the Committee on the Planetary Science Decadal Survey (2023-2032) of the National Academies of Sciences/USA, and to the Artemis III Science Definition Team, representing the interests, objectives, and goals of the global LLR instrument, data analysis and observer community. In 2022, Dr. Viswanathan established the Goddard Lunar Data Analysis Center affiliated with the International Laser Ranging Service. Dr. Viswanathan is currently at NASA GSFC employed by UMBC under the CRESST II cooperative agreement.

EDUCATION

Ph.D., Astronomy and Astrophysics, Paris Observatory (IMCCE/PSL/OCA), France, 2017
M.S., Aero. & Space Systems Eng., National School of Aeronautics and Space Eng. (ISAE), France, 2013
B.Tech., Electronics and Communication Eng., National Institute of Technology, Trichy, India, 2011

PROFESSIONAL EXPERIENCE

2021 – present Assistant Research Scientist, UMBC/CRESST/GSFC, USA
 2019 – 2021 Post-doctoral Research Associate, UMBC/CRESST/GSFC, USA
 2017 – 2019 Post-doctoral Researcher, Paris Observatory, IMCCE/PSL, France
 2014 – 2017 Doctoral Researcher, Géoazur, Nice Observatory, France

LEADERSHIP ROLES

- Principal Investigator/Founder, ILRS Lunar Data Analysis Center at UMBC/GSFC, 2022-present
- Principal Investigator, Development of a High-Precision Dynamical Model of the Moon, 2022-2023
- Principal Investigator, Measuring Saturn's Dissipation using Cassini Astrometric Data, 2021-2024
- Principal Investigator, Analysis of LLR Data and Modeling of Lunar Interior, 2019-2022
- Principal Investigator, Retracing the Reorientation and Tidal History of the Moon, 2021-2023

GRANTS AWARDED

- NASA grant, ROSES Cassini Data Analysis Program, USA, 2021-2024
- NASA grant, GSFC ISFM Planetary Geodesy, USA, 2022-2023
- NASA grant, GSFC ISFM Planetary Geodesy, USA, 2021-2023
- NASA grant, GSFC ISFM Planetary Geodesy, USA, 2019-2022
- Postdoctoral grant, Space Exploration of Planetary Environments, France, 2017-2019
- Doctoral grant, Ministry of Higher Education, Research and Innovation, France, 2014-2017

PROPOSALS AWARDED

- Co-Investigator, Observation of Lunar Node using National Radio Astronomy Observatory's Very Long Baseline Array (VLBA) network ~ 18h, 2022
- Collaborator, Internal Research and Development, NASA/GSFC, USA, 2020-2022
- International Collaborator, Lunar Tidal Deformation from Earth-based and Orbital Laser Ranging, Bilateral Agreement: French National Research Agency (ANR)/German Science Foundation (DFG), 2019-2022

MEMBERSHIPS

- Member, International Astronomical Union, 2022-present
- Associate member, International Laser Ranging Service, 2022-present
- Science Team member, Lunar Geophysical Network Mission - NASA NF5 AO, 2021-present
- Affiliate, International Association of Geodesy, 2022-present
- Affiliate, Division for Planetary Sciences of the American Astronomical Society, 2021-present
- Affiliate, American Geophysical Union, 2019-present
- Affiliate, European Geophysical Union, 2017-present

PROFESSIONAL AND COMMUNITY SERVICE

- Session Chair, "Moon", 53rd Meeting of the AAS Division for Planetary Sciences, 2021
- Reviewer for international scientific journals: *Astronomy & Astrophysics* (2), *Advances in Space Research* (3), *Celestial Mechanics and Dynamical Astronomy* (1), *Earth and Space Science* (2), *Journal of Geodesy* (1), *Journal of Geophysical Research: Planets* (3), *The Astrophysical Journal Letters* (1), *The Planetary Science Journal* (3), *Universe* (2)
- Reviewer for NASA HQ's ROSES program; 3 as Panelist ('21, '20, '19) and 1 as External Reviewer ('20); Total of 38 proposals.

SUPERVISION & TEACHING

- L. Aber (co-adv., Prof. A. Fienga), 1st year Master in Fund. Phys. & Appl., Sorbonne Univ., Paris, 2020
- E. N. Reksini (co-adv., Prof. N. Rambaux), 2nd year Master in Dyn. of Grav. Systems, Paris Obs., 2018
- Satellite Systems, Grad., University of Nice, Sophia Antipolis, France, 2017
- Thermodynamics, Undergrad., ESAIP Graduate School of Eng., Grasse, France, 2016

SCIENTIFIC OUTREACH

- Lead Scientist, "Lunar Polar Wander", NASA Scientific Visualization Studio, September 19, 2022
<https://svs.gsfc.nasa.gov/5023>
- NASA expert, "Episode 42 – Watch a Total Lunar Eclipse", NASA Science Live, May 15, 2022
https://images.nasa.gov/details-GSFC_20220515_NSL_Ep42
- Science Advisor, Public Engagement Team, Solar System Exploration Div., NASA GSFC, 2021-present
"Moon in Motion", article published on NASA webpage <https://moon.nasa.gov/moon-in-motion/tides/>
- Volunteer at 50th Anniversary: Apollo Moon Landing, National Mall, Washington D.C., USA, 07/2019

PRESS RELEASES

- 2022 "Small Craters Add Up to Wandering Poles on Moon" <https://tinyurl.com/pole-wander>
A press release by NASA GSFC on research article published in *The Planetary Science Journal*.
- 2020 "Laser Beams Reflected Between Earth and Moon Boost Science" <https://tinyurl.com/y3f43sut>
A press release by NASA GSFC on research article published in *Earth, Planets and Space*.
- 2019 "New estimate of the size of the Moon's core using lunar laser ranging" <https://tinyurl.com/yxonerss>
A press release by the National Centre for Scientific Research, France (CNRS) on research article published in *Geophys. Res. Lett.*; Work cited by The New York Times <https://tinyurl.com/moon-laser>
- 2018 "Testing the universality of free fall with lunar laser" (translated; originally in French)
A feature article in the French scientific magazine "La Recherche" based on research article published in *Mon. Not. R. Astron. Soc.* <https://tinyurl.com/moon-free-fall>

PUBLICATIONS

(Refereed)

- Ray, R.D., **Viswanathan, V.**, Chao, B.F., “Is there a six-year ocean tide?”, *Scientific Reports* (submitted)
- Briaud, A., and 10 co-authors (incl. **Viswanathan, V.**) “Constraints on the lunar deep interior from tidal deformation”, *Icarus* (under revision)
- Smith, D.E., **Viswanathan, V.**, Mazarico, E., et al. 2022, “The Contribution of Small Impact Craters to Lunar Polar Wander”, *The Planetary Science Journal*, 3(9), 217. doi:10.3847/PSJ/ac8c39
- Ermakov, A., and 15 co-authors (incl. **Viswanathan, V.**) 2021, “A Recipe for Geophysical Exploration of Enceladus”. *The Planetary Science Journal*, 2(4), 157. doi:10.3847/PSJ/ac06d2
- Mazarico, E., and 19 co-authors (incl. **Viswanathan, V.**) 2020, “First Two-way Laser Ranging to a Lunar Orbiter: infra-red observations from the Grasse station to LRO’s retro-reflector array”. *Earth Planets Space* 72, 113; doi:10.1186/s40623-020-01243-w
- **Viswanathan, V.**, Rambaux, N., Fienga, A., Laskar, J., Gastineau, M. 2019, “Observational Constraint on the Radius and Oblateness of the Lunar Core-Mantle Boundary”. *Geophysical Research Letters* 46, 7295–7303; doi:10.1029/2019GL082677
- **Viswanathan, V.**, Fienga, A., Minazzoli, O., Bernus, L., Manche, H., Laskar, J., Gastineau, M. 2018, “The new lunar ephemerides INPOP17a and its application to fundamental physics”. *Monthly Notices of the Royal Astronomical Society* 476, 1877–1888; doi:10.1093/mnras/sty096
- Courde, C., and 10 co-authors (incl. **Viswanathan, V.**) 2017, “Lunar laser ranging in infrared at the Grasse laser station”. *Astron. Astrophys.* 602, A90; doi:10.1051/0004-6361/201628590

(Books/Technical Notes)

- Fienga, A., Deram, P., Ruscio A. Di., **Viswanathan, V.**, Camargo, J. I. B., Bernus, L., Gastineau, M., Laskar, J. 2021, “INPOP21a planetary ephemerides”. *Notes Scientifiques et Techniques de l’Institut de Mécanique Céleste*, ISBN 978-2-910015-84-8, 110, 19 pp.
- Fienga, A., Deram, P., **Viswanathan, V.**, Ruscio A. Di., Bernus, L., Durante, D., Gastineau, M., Laskar, J. 2019, “INPOP19a planetary ephemerides”. *Notes Scientifiques et Techniques de l’Institut de Mécanique Céleste*, ISBN 978-2-910015-81-7, 109, 35 pp.
- **Viswanathan, V.**, Fienga, A., Manche, H., Laskar, J., Gastineau, M. 2017, “INPOP17a planetary ephemerides”. *Notes Scientifiques et Techniques de l’Institut de Mécanique Céleste*, ISSN 1621-3823, ISBN 2-910015-79-3, 108, 39 pp.

(Community white papers)

- Cremons, D. et al. (incl. **Viswanathan, V.**) 2022, “The Contribution of Active Spectroscopy to Orbital Remote Sensing of Lunar Volatiles”, *LEAG Continuous Lunar Orbital Capabilities Specific Action Team (CLOC-SAT)* (submitted)
- **Viswanathan, V.**, Mazarico, E., Merkowitz, S., Williams, J. G., Turyshev, S. G., Currie, D. G., et al. (2021). “Extending Science from Lunar Laser Ranging”. *Bulletin of the AAS*, 53(4); doi:10.3847/25c2cfcb.3dc2e5e4
- Porcelli, L., and 40 co-authors, incl., **Viswanathan, V.** 2021, “Next Generation Lunar Laser Retroreflectors for Fundamental Physics and Lunar Science”, *White paper submitted to Decadal Survey on Biological and Physical Sciences Research in Space 2023-2032*, NTRS ID: 20210025424
- Ermakov, A.I., Castillo-Rogez, J.C., Park, R.S., Sotin, C., Lazio, J., Howell S.M., Keane, J.T., Hemingway., Nimmo, F., Kite, E., **Viswanathan, V.** et al. (2021) “A recipe for geophysical exploration of Enceladus”. *Bulletin of the AAS*, 53(4); doi:10.3847/25c2cfcb.b65f2c4c
- **Viswanathan, V.**, Mazarico, E., Merkowitz, S., Sun, X., Eubanks, T. M., & Smith, D. E. (2020). “Next-Generation Geodesy at the Lunar South Pole: An Opportunity Enabled by the Artemis III Crew”. *Artemis III Science Definition Team Whitepaper #2077*.

(Proceedings)

- Baguet, D. et al. (incl. **Viswanathan, V.**) 2022, “Introduction of tidal models in lunar ephemerides”, *Europlanet Science Congress 2022, Granada, Spain*, doi:10.5194/epsc2022-978
- **Viswanathan, V.**, Smith, D. E., Mazarico, E., Goossens, S., Head, J. W., Neumann, G. A., Zuber, M. T. (2022). Small Impact Craters Steered the Early Moon’s Pole Along the Earth-Moon Direction. In *European Lunar Symposium*
- **Viswanathan, V.**, Liounis, A. J., Mazarico, E., Goossens, S., Neveu, M. (2022). Astrometric Reduction of Phoebe using a Digital Shape Model. In *Lunar and Planetary Science Conference* (p. 2224)
- Smith, D. E., **Viswanathan, V.**, Mazarico, E., Goossens, S., Head, J. W., Neumann, G. A., Zuber, M. T. (2022). A Geodetic Approach to Estimate the Contribution of Impact Craters and Basins to the Moon’s Low-Degree Gravity Field. In *Lunar and Planetary Science Conference* (p. 1283)
- **Viswanathan, V.**, Mazarico, E., Barker, M. K., Cremons, D. R., & Smith, D. E. (2021). The Case for a Retroreflector in a Lunar South Polar Shadowed Region. In *Lunar Surface Science Workshop: Landing Sites and Capabilities for Future CLPS deliveries* (#8026)
- **Viswanathan, V.**, Mazarico, E., & Goossens, S. (2021). A Simulation Study for Extending Lunar Laser Ranging Science. In *Lunar and Planetary Science Conference* (p. 2651).
- **Viswanathan, V.**, Mazarico, E., Goossens, S., Rambaux, N., & Smith, D. E. (2020). Estimating the Lunar Core Equatorial Ellipticity Using Lunar Laser Ranging. In *Lunar and Planetary Science Conference* (p. 2031).
- **Viswanathan, V.**, Mazarico, E., Cremons, D., Merkowitz, S., Sun, X., & Smith, D. E. (2020). Scientific Exploration of the Lunar South Pole with Retro-Reflectors. *LPI Contributions, 2241*(Lunar Surface Science Workshop), 5070.
- Fienga, A., **Viswanathan, V.**, Deram, P., Di Ruscio, A., Bernus, L., Laskar, J., et al. (2020). INPOP new release: INPOP19a. *Astrometry, Earth Rotation, and Reference Systems in the GAIA Era*, 293–297.
- Rambaux, N., **Viswanathan, V.**, Fienga, A., Laskar, J., & Gastineau, M. (2020). A New Dynamical Model of the Lunar Core and Improved Observational Constraints from Lunar Laser Ranging. In C. Bizouard (Ed.), *Astrometry, Earth Rotation, and Reference Systems in the GAIA era* (pp. 303–307).
- Rambaux, N., **Viswanathan, V.**, Fienga, A., Laskar, J., & Gastineau, M. (2019). Dynamical Model of Lunar Core and Observational Constraint from Lunar Laser Ranging. In *EPSC-DPS Joint Meeting 2019* (Vol. 2019, p. EPSC--DPS2019).
- Chen, H., Gastineau, M., Hestroffer, D., **Viswanathan, V.** 2018, Parallel High-fidelity Trajectory Optimization with Application to CubeSat Deployment in an Earth-moon Halo Orbit. *Proc. of the 7th Interplanetary CubeSat Workshop*, Paris, France, May 29-30.
- Courde, C., Torre, J.M., Samain, E., Martinot-Lagarde, G., Aimar, M., Albanese, D., Maurice, N., Mariey, H., Viot, H., Exertier, P., Fienga, A., and **Viswanathan, V.** 2017, Satellite and Lunar Laser Ranging in Infrared. *Proc. SPIE 10229, Photon Counting Applications*, doi:10.1117/12.2270573;
- Minazzoli, O., Bernus, L., Fienga, A., Hees, A., Laskar, J., **Viswanathan, V.** 2017, Universality of Free Fall versus Ephemeris. *Proc. of the 52th Rencontres de Moriond*
- **Viswanathan, V.**, Fienga, A., Manche, H., Courde, C., Torre, J.M., Exertier, P., Laskar, J. 2016, Updates from INPOP ephemerides: Data Reduction Model and Parameter Estimation using IR LLR data from OCA”. *20th International Workshop on Laser Ranging*.

TALKS

- “Orientation of the Moon using Lunar Laser Ranging data & GRAIL gravity field”, ESI-Solid Earth Team Meeting, 11/2022 (invited)
- “Extending Science from Lunar Laser Ranging data”, Joint Seminar: Geodesy & Geophysics Laboratory; Planetary Geology, Geophysics & Geochemistry Laboratory at NASA GSFC, 04/2021 (invited)
- “Scientific Exploration of the Lunar South Pole with Retro-Reflectors”, Lunar Surface Science Workshop, LPI #2241, id. 5070, 04/2020
- “Updates from INPOP ephemeris: From fundamental physics tests to lunar interior probe”, 42nd COSPAR Scientific Assembly, H0.5-0006-18, 07/2018

- “Recent updates from the INPOP lunar and planetary ephemeris team”, Journées Scientifiques du Programme National GRAM, #215219, 06/2018
- “LLR data analysis and impact on lunar dynamics from recent developments at OCA LLR Station”, EGU General Assembly Conference, Vol. 18, p. 13995, 04/2016
- “Recent developments in INPOP planetary ephemerides”, IAU General Assembly, 22, p. 27116, 8/2015

POSTERS

- **Viswanathan, V.**, Mazarico, E. (2020). Exploring the Moon with retroreflectors, In *AGU Fall Meeting Abstracts* (Vol. 2020, pp. P081-0006)
- Mazarico, E., Barker, M.K., Saxena, P., Cremons, D.R., **Viswanathan, V.**, Sun, X. (2020). Dynamics, Dust and Regolith Environment, ‘Earth as an Exoplanet’, and Exploration from the Moon Surface (DDRE4MS), *Annual Meeting of the Lunar Exploration Analysis Group*, 5044.
- **Viswanathan, V.**, Mazarico, E., Goossens, S. J., & Bertone, S. (2019, December). On the GRAIL-LLR low-degree gravity field inconsistencies. In *AGU Fall Meeting Abstracts* (Vol. 2019, pp. G31B-0649).
- **Viswanathan, V.**, Fienga, A., Laskar, J., Manche, H., Torre, J-M., Courde, C., Exertier, P. (2015). Utilizing the Lunar Laser Ranging datasets alongside the radioscience data from the Lunar Reconnaissance Orbiter to improve the dynamical model of the Moon, *IAU General Assembly*, 29, 2228567
- Memin, A., **Viswanathan, V.**, Fienga, A., Santamaría-Gómez, Boy, J-P. (2016). Multi-geodetic characterization of the seasonal signal at the CERGA geodetic reference, France. In *AGU Fall Meeting Abstracts* (Vol. 2016, pp. G33B-1093)