Fundamental Physics in Space Missions, Asteroid Tracking, and Quantum Sensors

Dark Matter, Cosmic Neutrinos, and Fifth Forces

1. Tsai, et al., Nature Astronomy (2022) 2112.07674, featured by DOE Office of Science

2. Tsai et al., https://arxiv.org/abs/2210.03749

3. Tsai et al., JCAP (2023), https://arxiv.org/abs/2107.04038

$1.5 billion

OSIRIS-Rex

Asteroid sample return and tracking

$1.16 billion

$80 million

Ongoing

Completed

Photo credits: NASA

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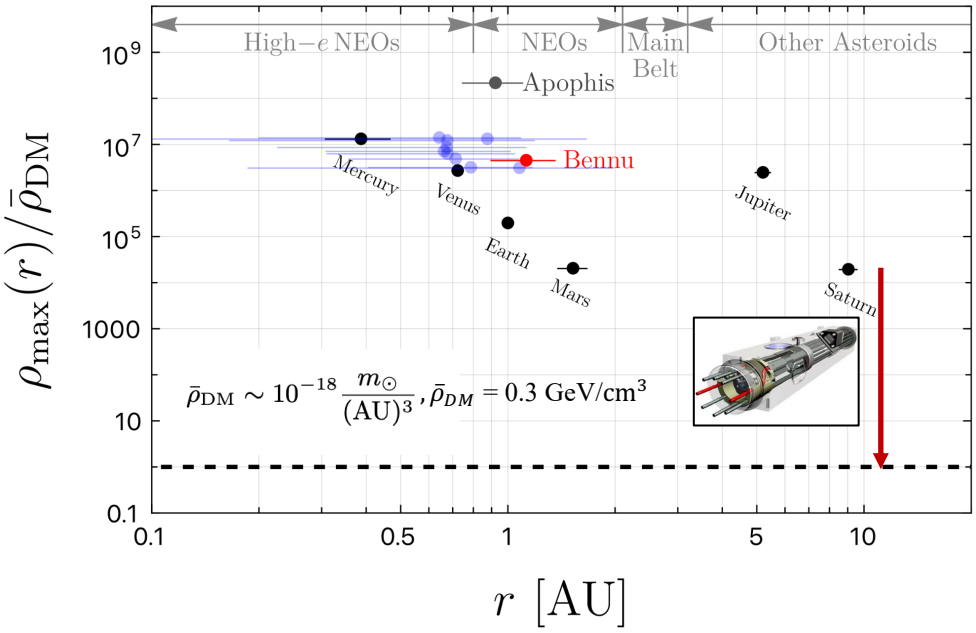
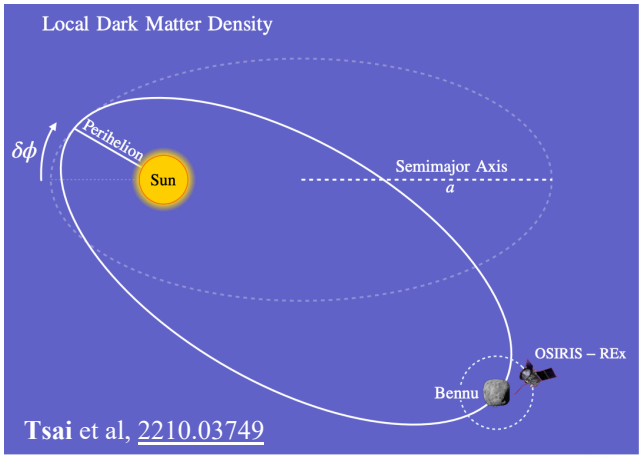
INSPIRE-HEP: https://inspirehep.net/authors/1274923

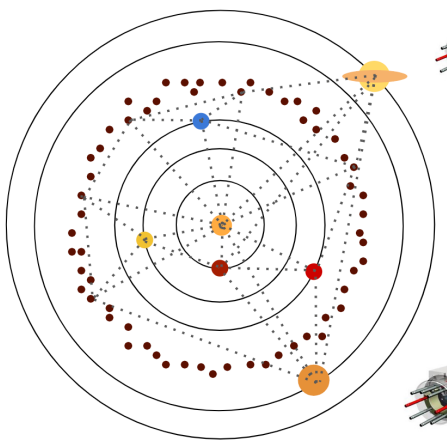
Ultra-Precision Asteroid Tracking by OSIRIS Mission & Telescopes

Study Local Dark Matter, CvB, & Hidden Fifth Forces

1. **Tsai** et al., https://arxiv.org/abs/2210.03749
2. **Tsai** et al., JCAP (2023), https://arxiv.org/abs/2107.04038







NASA
Deep Space Atomic Clock

Using the **Asteroid Tracking Network (ATN)** for Fundamental Physics

1. Study **astrometry & precessions**
2. Can study **local dark matter density**, **cosmic background neutrinos**, and **long-range fifth forces**
3. Increase precision with **new technologies** (e.g., with quantum clocks onboard of space missions)

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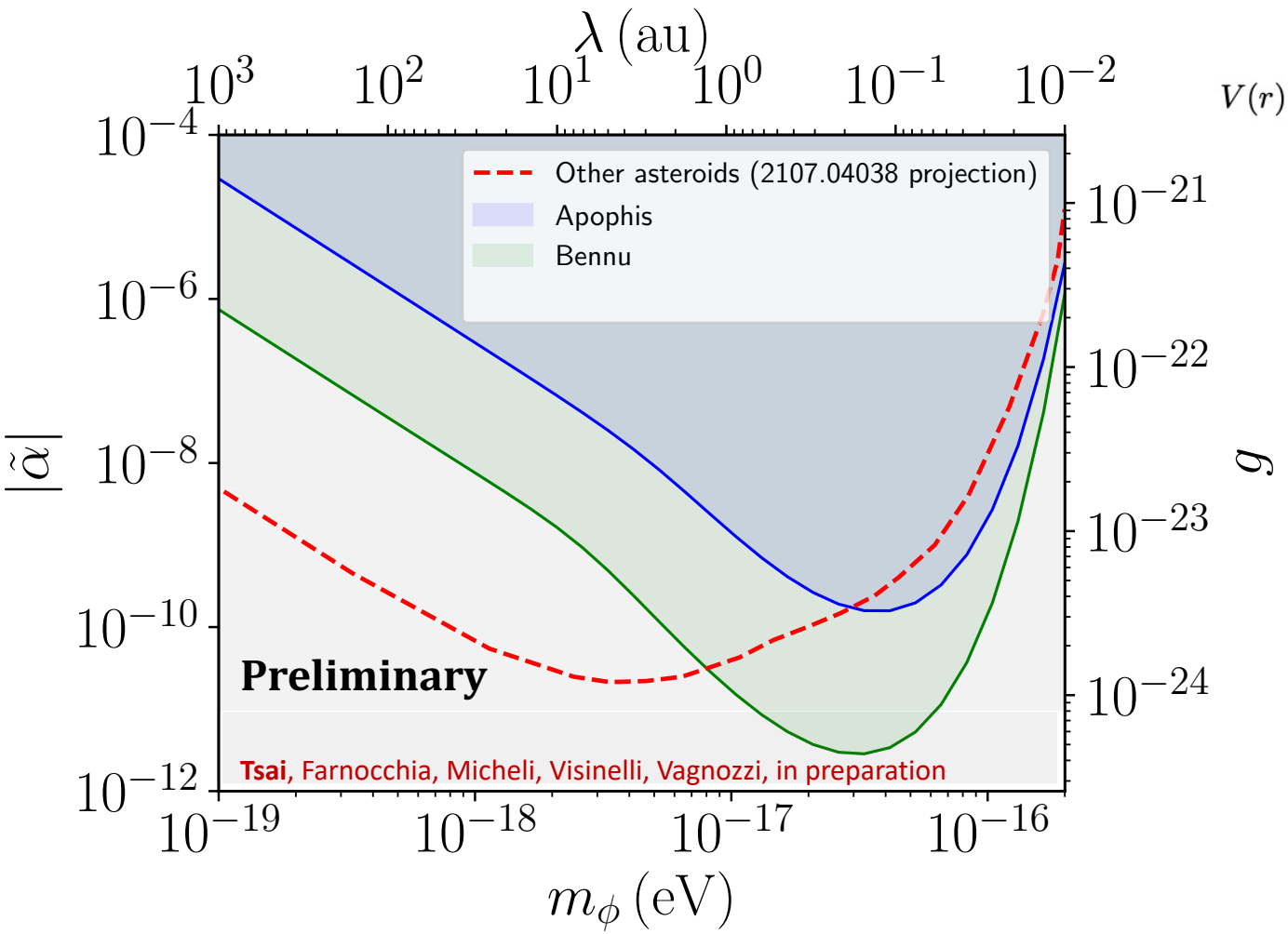
New Bennu (OSIRIS-Rex) & Apophis Constraints

Gauging $U(1)_B$

$$V(r) = \mp \frac{g^2}{4\pi} \frac{Q_\odot Q_*}{r} \exp\left(-\frac{mc^2}{\hbar c} r\right)$$



SpaceQ - Space Quantum Sensor for Ultralight Dark Matter

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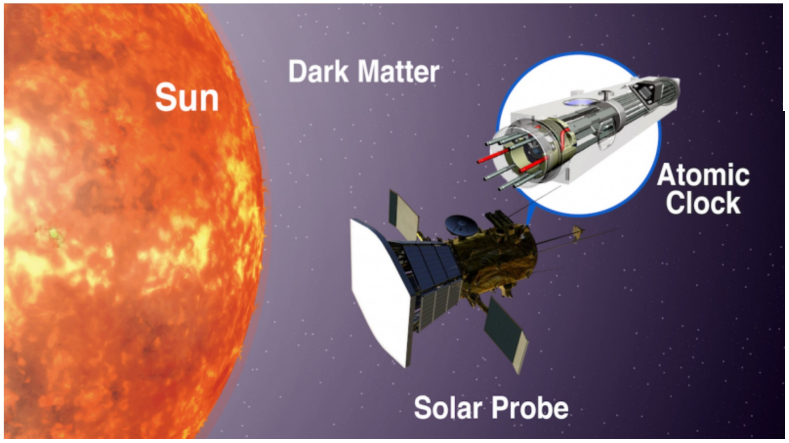
3. Tsai, et al., Nature Astronomy (2022) 2112.07674, featured by DOE Office of Science

Propose **a two-clock comparison experiment** onboard **future solar probes**



$$\phi(t,\vec{x}) = \phi_0 \cos(m_\phi t - \vec{k}_\phi \cdot \vec{x} + \dots).$$
$$\omega \simeq m_\phi.$$
$$\mathcal{L} \supset \left(\frac{\sqrt{\pi} d_\alpha}{2M_P}\right) \phi F_{\mu\nu} F^{\mu\nu}$$