ESA/Hubble, NASA, ESO, M. Kornmesser

New Constraints on Cometary Activity of ‘Oumuamua from Lyman-Alpha Images Obtained by SOHO/SWAN

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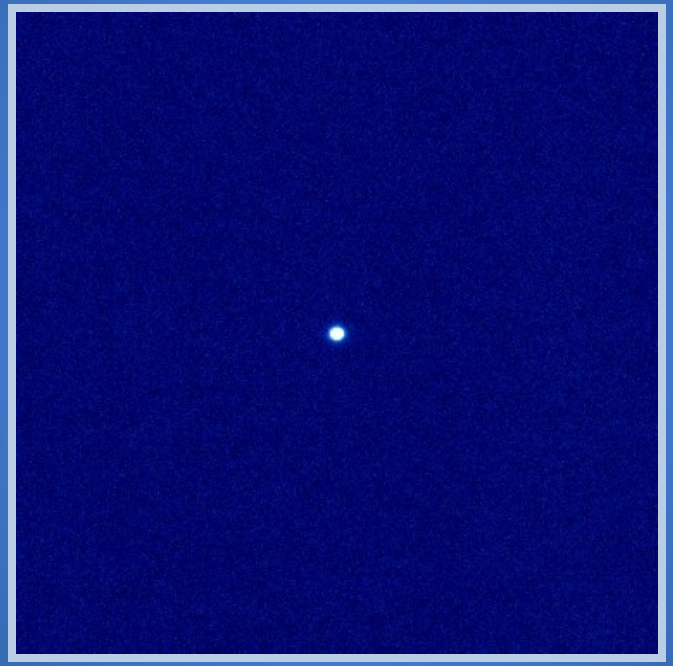
‘Oumuamua: no signs of coma

- High brightness variations (2.6 mag)
- Non-principal axis rotation (tumbling)
- No signs of dust/gas emission



The deepest image of ‘Oumuamua from Gemini North (Drahus et al. 2018)

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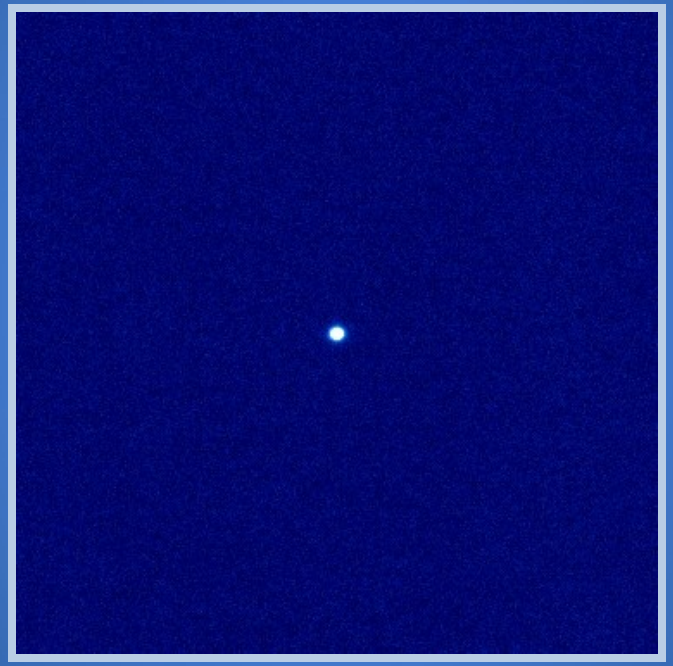
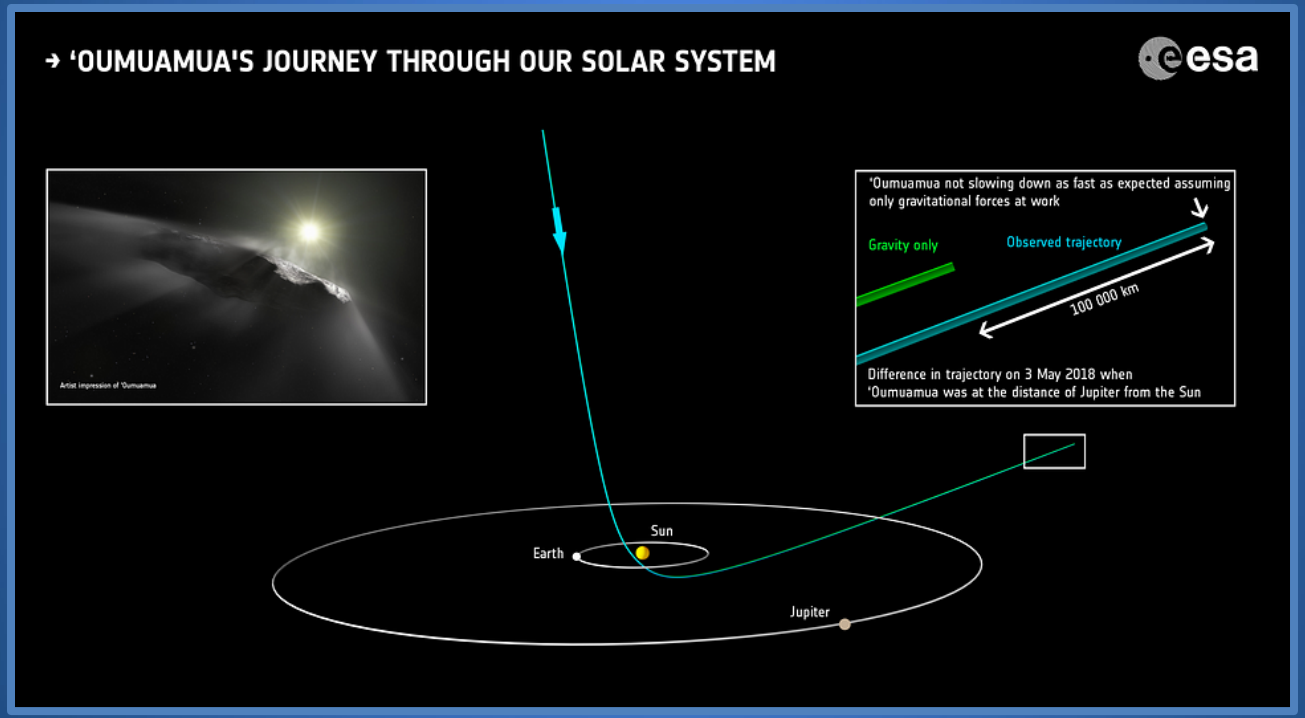


elongated asteroid?

The deepest image of ‘Oumuamua from Gemini North (Drahus et al. 2018)

Orbital anomalies

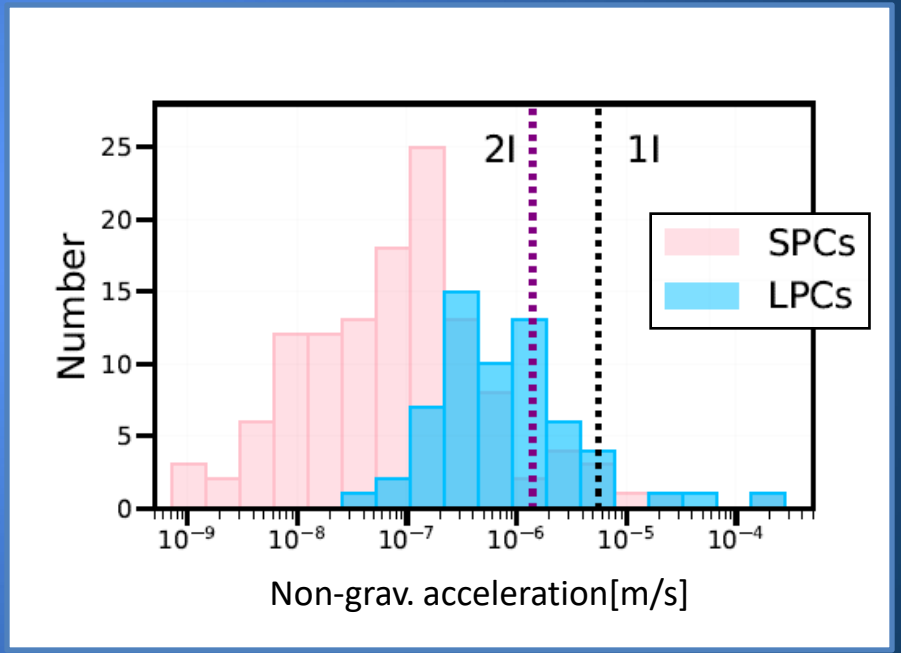


Non-gravitational acceleration

- One of the strongest NGA ever measured
- NGA – heliocentric distance dependence: ~ 1/r or $1/r^2$

ESA\Rosetta

(from Jewitt & Seligman 2022)



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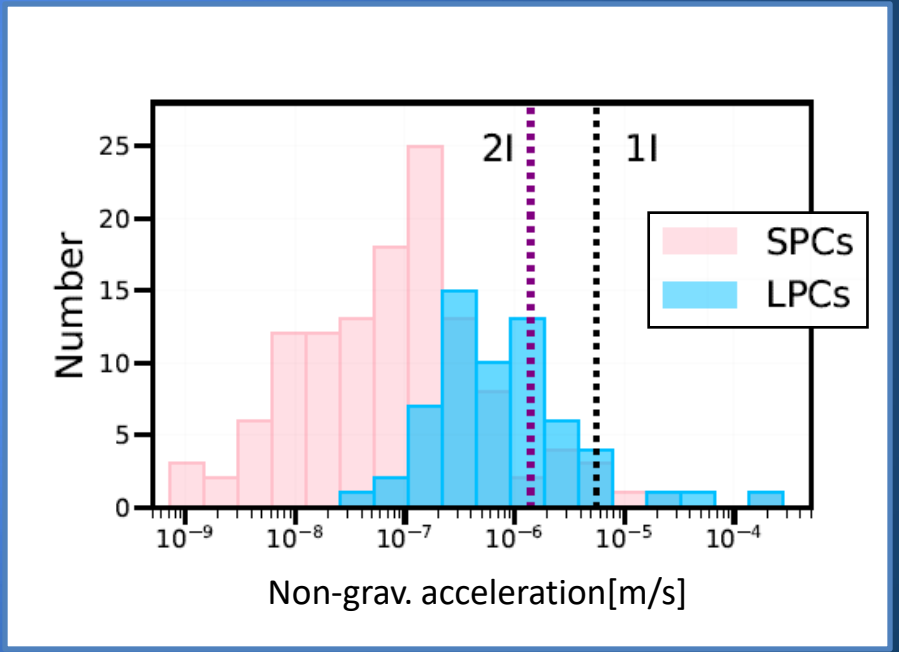
ESA\Rosetta

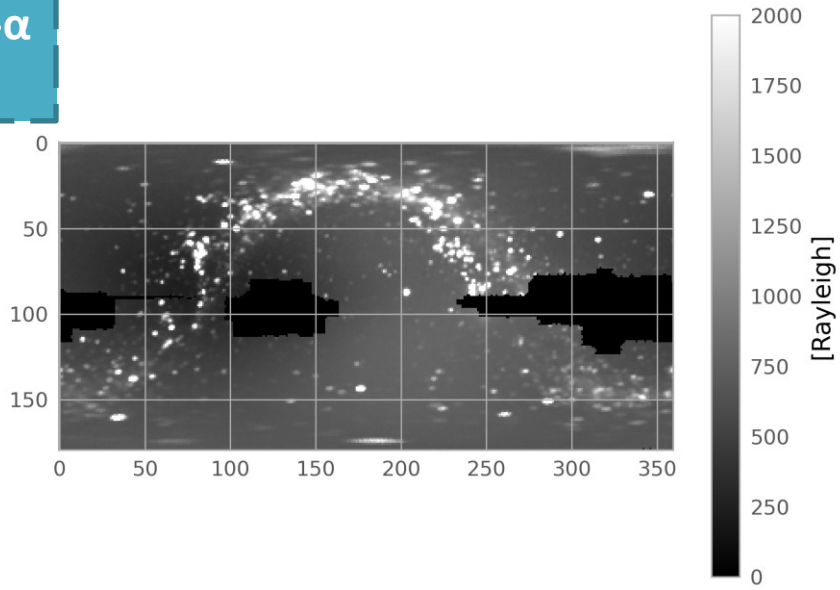
peculiar comet?

(from Jewitt & Seligman 2022)



Searching for 1I on SOHO/SWAN data

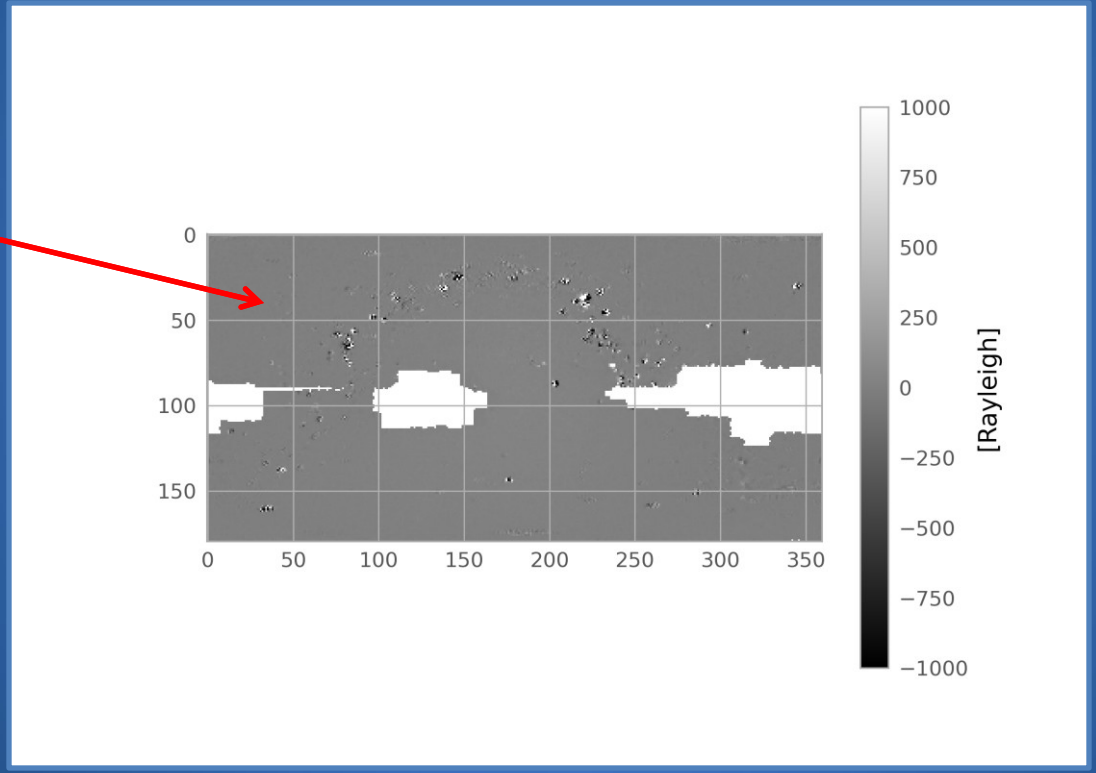
SOHO/SWAN:
- **All-sky imager in Ly-α**
- **1 full-sky map / day**



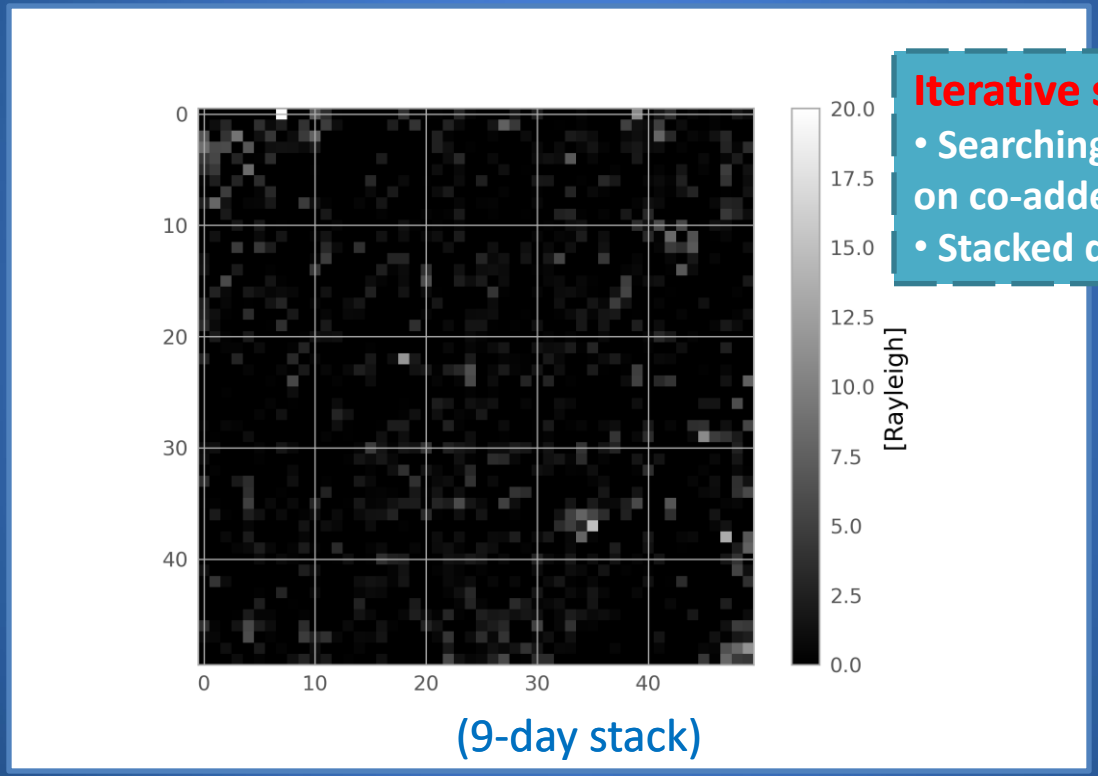
(single image)

Searching for 1I on SOHO/SWAN data

Stars' signal removed



Searching for 1I on SOHO/SWAN data



(9-day stack)

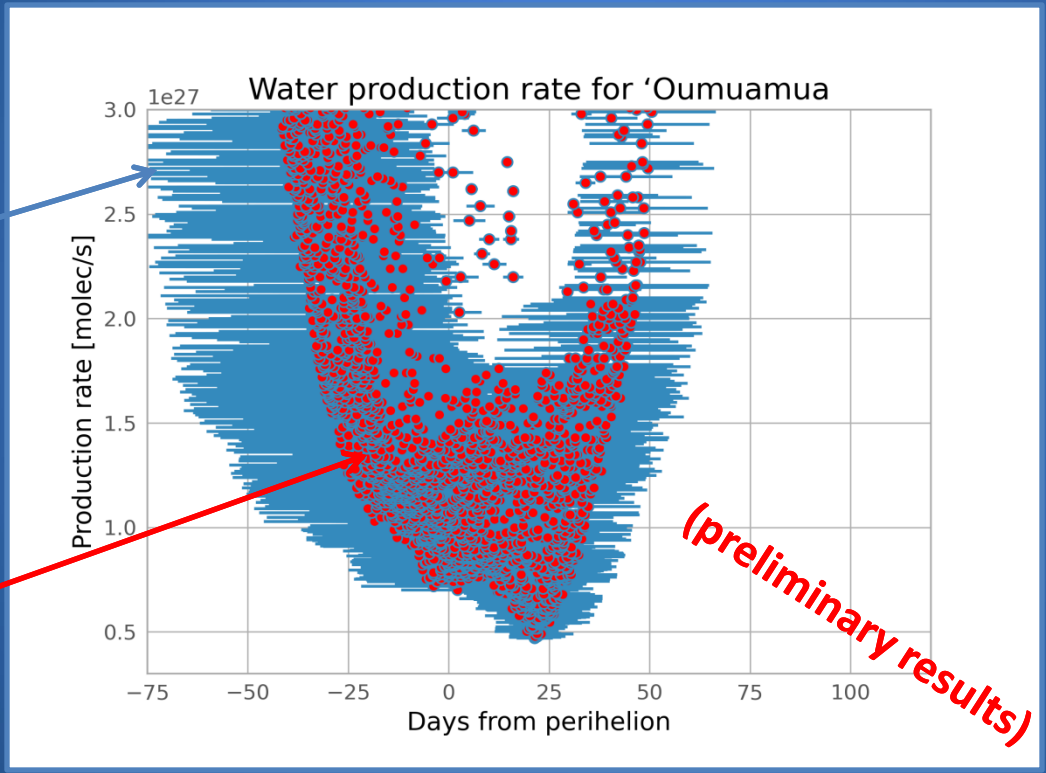
Iterative stacking method:

- Searching for faint emission on co-added images
- Stacked data period: 3-75 days

Searching for 1I on SOHO/SWAN data

Stacked period

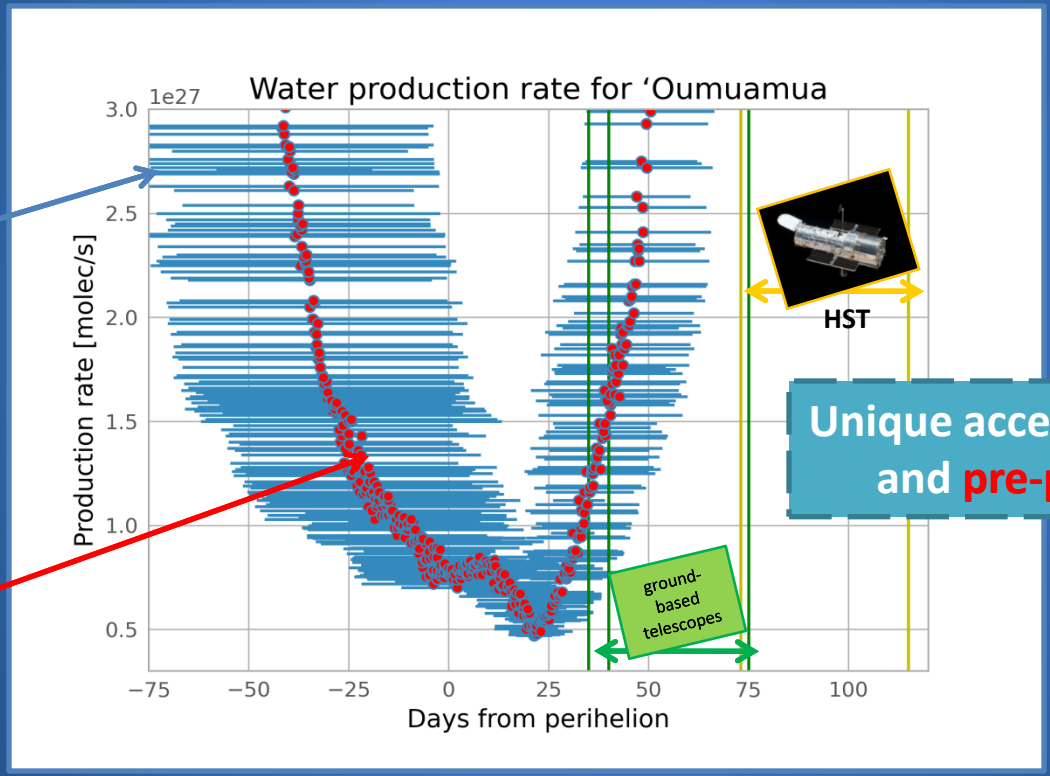
Upper limits on object's water production rate (3-sigma)
Model: Haser 1957



Upper limits on water production rate

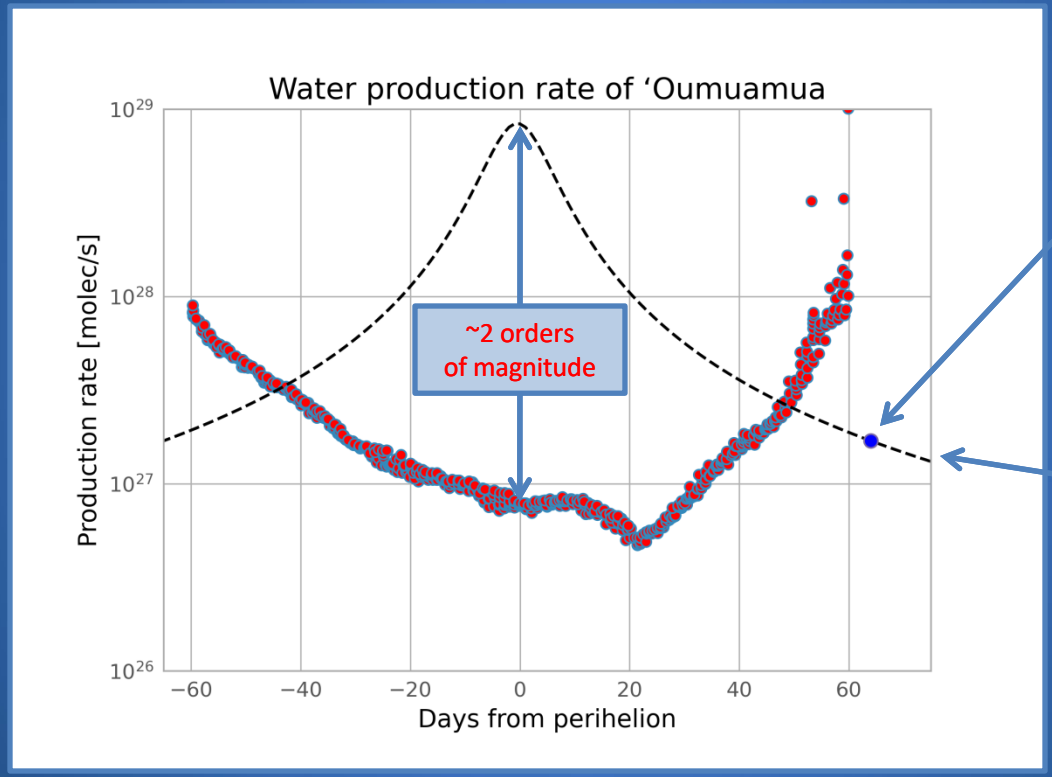
Stacked period

Selected lowest upper limits on object's $Q(H_2O)$



Unique access to prediscovery and pre-perihelion data!

SOHO/SWAN upper limits in context

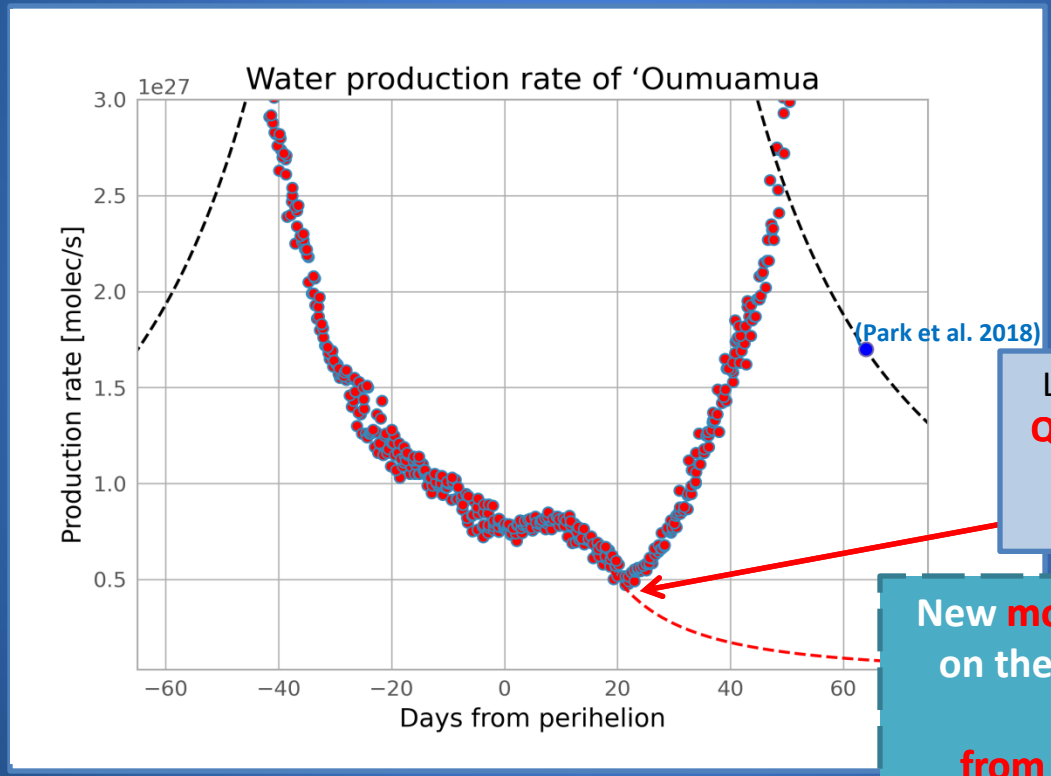


Q(OH) < 1.7·10^{27} molec/s at r =1.8 au

Upper limit from the non-detection of OH-18 cm emission - the lowest direct limit to date (Park et al. 2018)

OH production rate extrapolated assuming Q(r) ~ 1/r^2 and Q(OH) ≈ Q(H$_2$O)

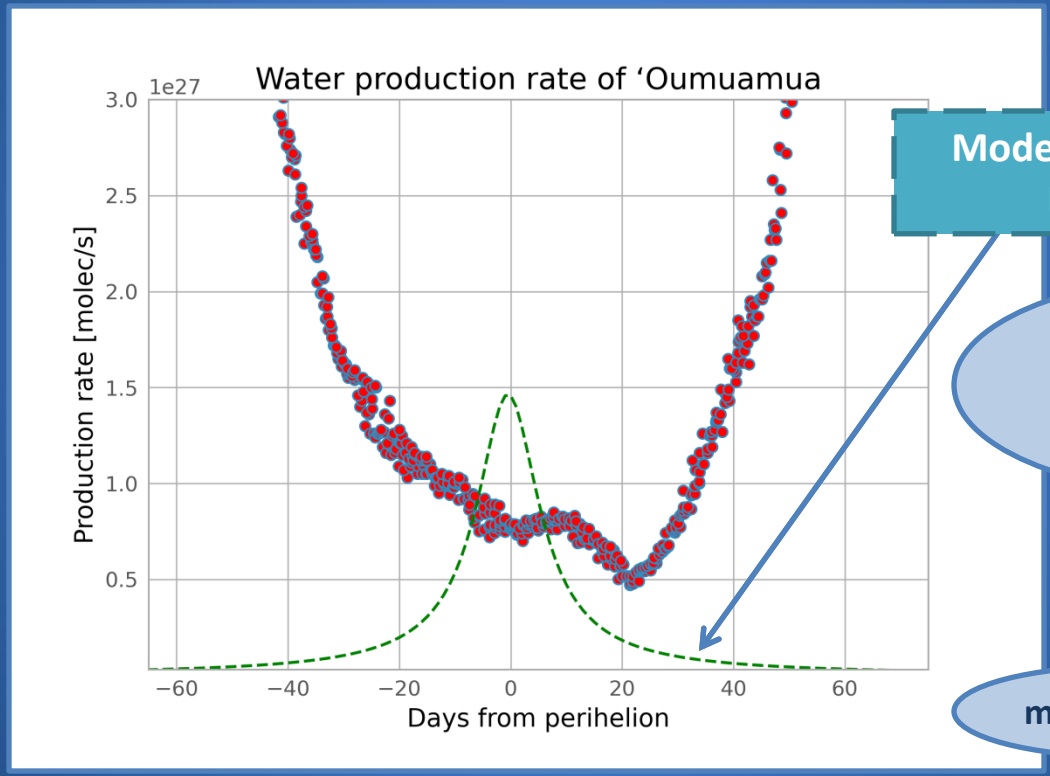
SOHO/SWAN upper limits in context



Lowest limit from our data:
$Q(H_2O) < 4.75 \cdot 10^{26}$ molec/s
at r = 0.75 au
(from 9-day stack)

New most rigorous upper limits on the water production rate of ‘Oumuamua from direct measurements

New constraints on H_2O emission



Model of H_2O mass-loss from Micheli et al. 2018

Properties of a typical comet nucleus

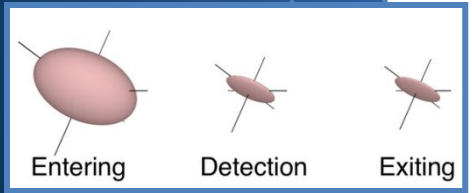
H_2O and CO outgassing

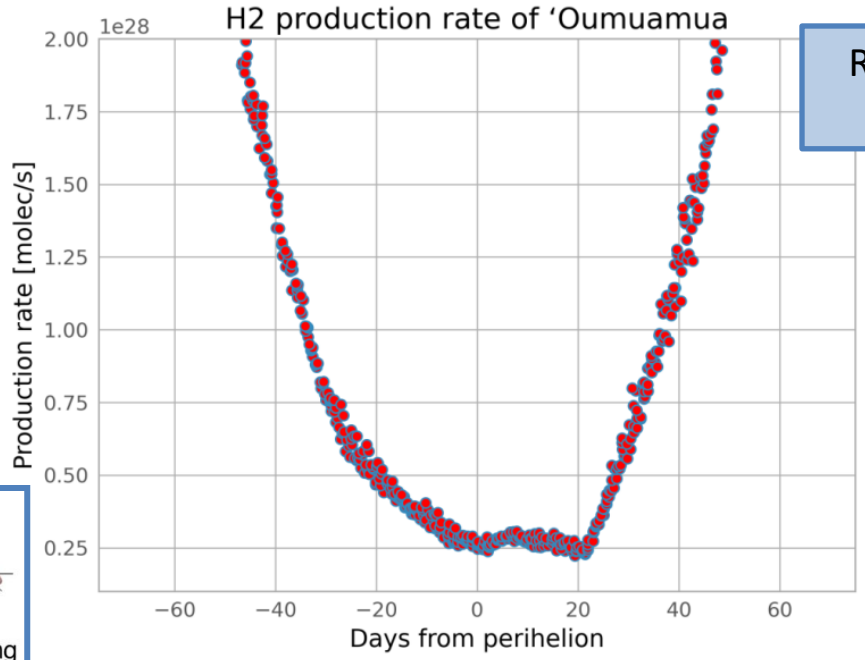
mm-size dust

Molecular hydrogen

H_2 iceberg
(Seligman 2020)

Couldn't survive





Radiolytic H_2O -> H_2 processing
(Bergner & Seligman 2022)

Cometary mass, density and structure

Hydrogen emission

Testing outgassing scenarios

If non-gravitational force is purely due to outgassing, then:

$$M\, a(r) = Q_{mol}\, m_{mol}\, v_{mol}\, \chi$$

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Non-gravitational acceleration

Testing outgassing scenarios

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$$M\, a(r) = Q_{mol}\, m_{mol}\, v_{mol}\, \chi$$

Gas production rate [molecules / s]

Molecular mass

Gas ejection speed

Measured upper limits

Testing outgassing scenarios

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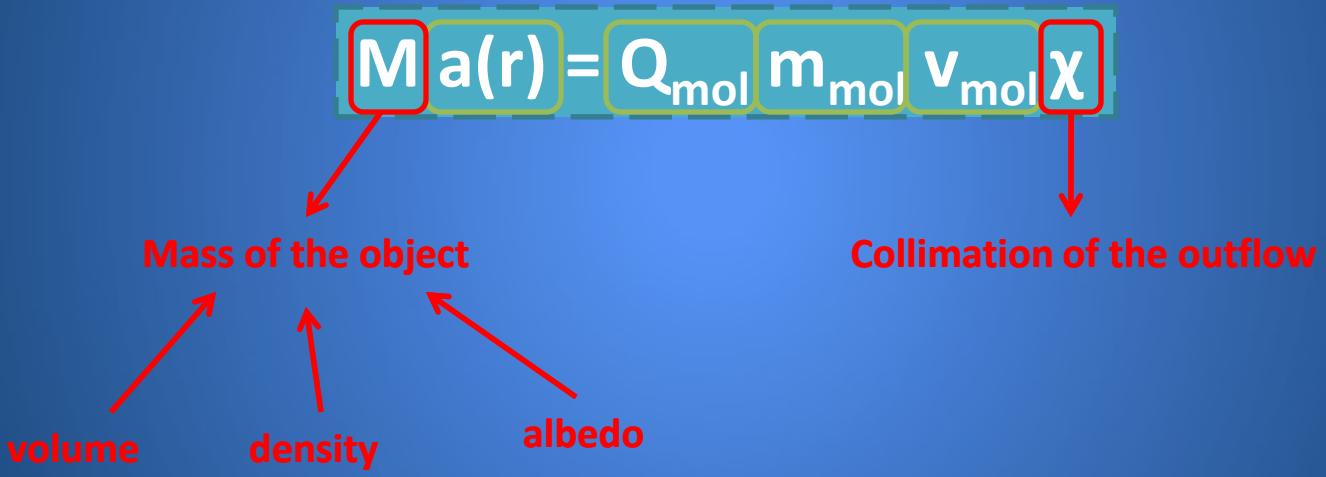
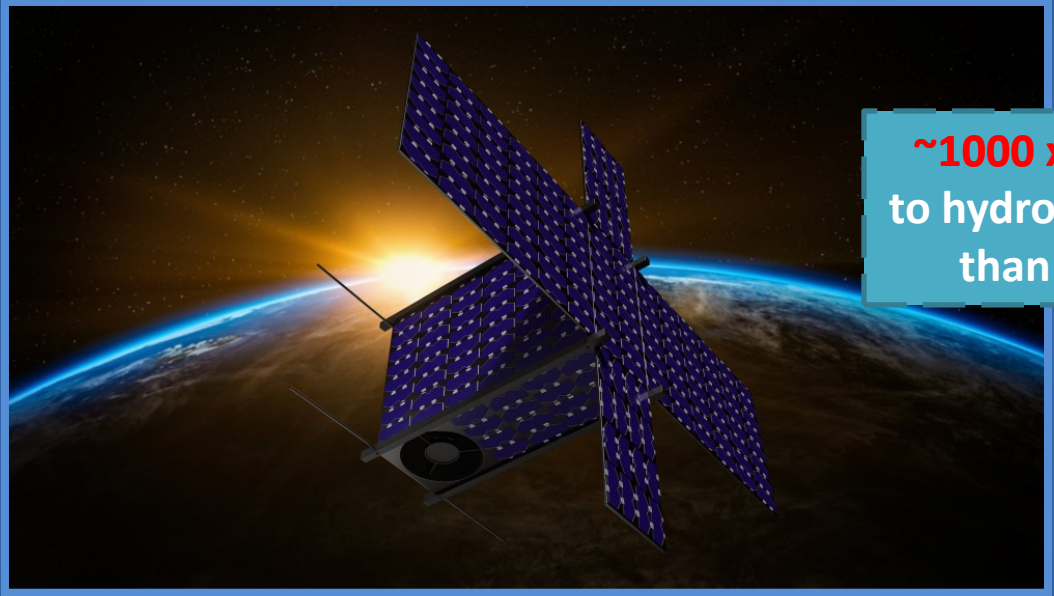


Future prospects: HYADES

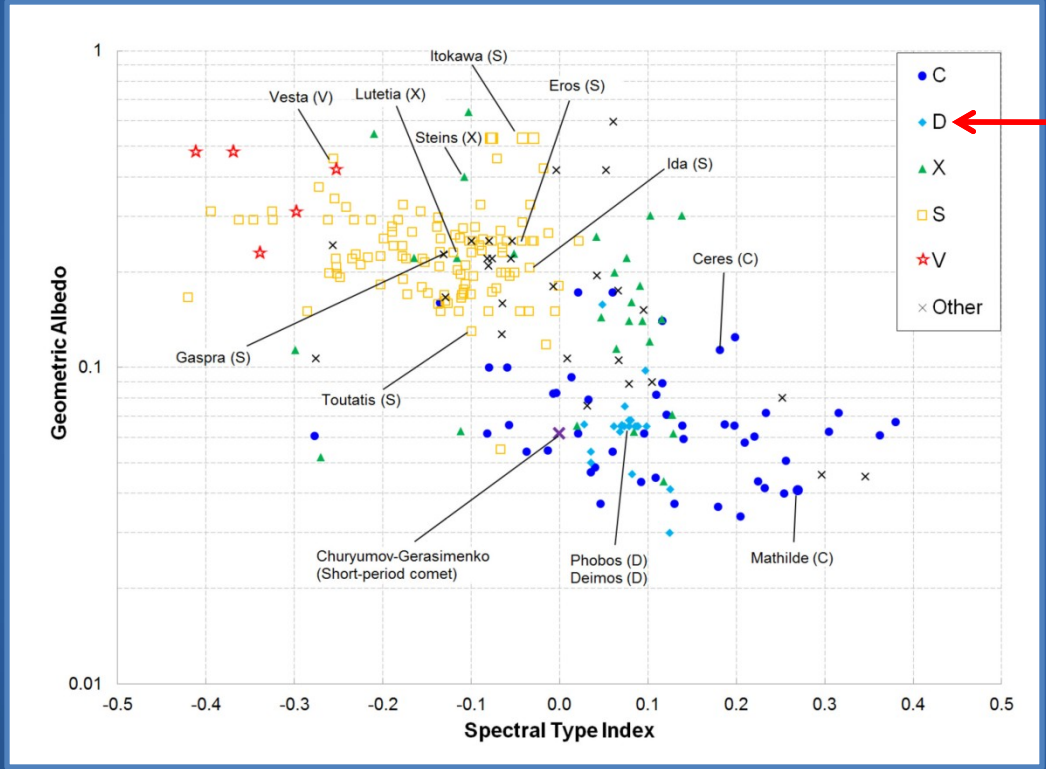


~1000 x more sensitive
to hydrogen Lyman-alpha
than SOHO/SWAN

New Polish space telescope dedicated to hydrogen and deuterium around minor bodies

(see the talk by Michał Drahus on Friday)

Albedo is not a *free parameter*



'Oumuamua

(from Miyamoto et al. 2016)