Capability and science objectives of the Millimetron Space Observatory for the study of small bodies of the Solar System and exoplanets

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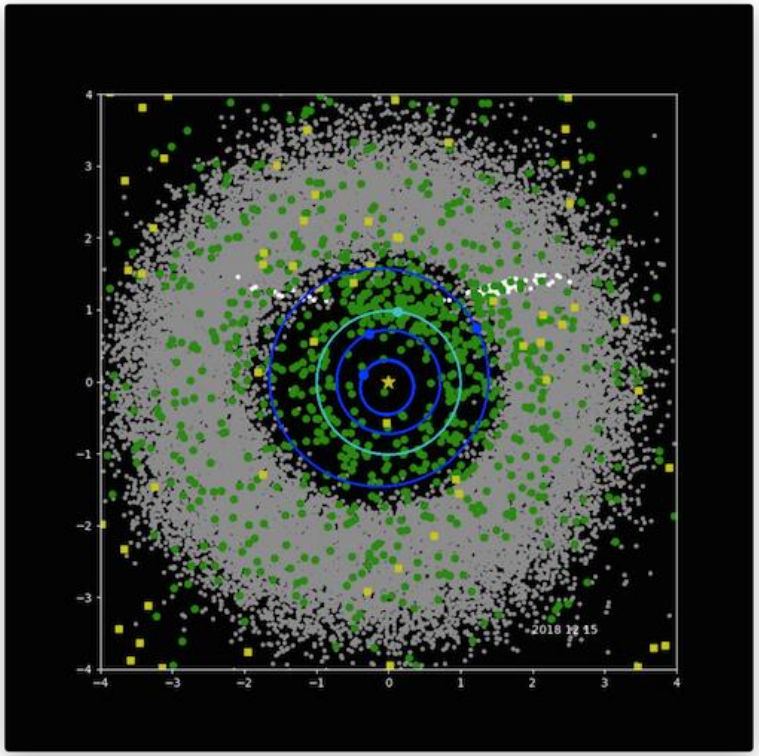
NEOWISE - 3.4 and 4.6 µm (W1 and W2)

http://wise2.ipac.caltech.edu/docs/release/neowise/



Main Belt asteroids (grey circles), Near Earth asteroids (green circles) and comets (yellow squares) detected by NEOWISE during the first five years

IRASSI INFRARED SPACE INTERFEROMETER: FORMATION GEOMETRY AND RELATIVE DYNAMICS ANALYSIS

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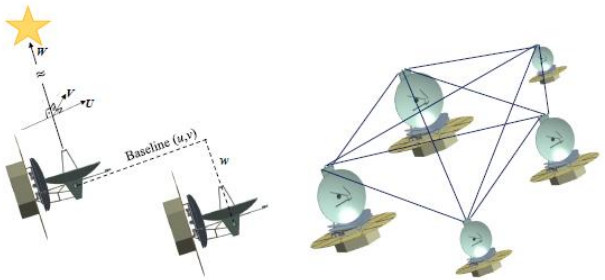
Table 1. IRASSI high-level science requirements.

Parameter	Required Value
Number of telescopes	5
Number of baselines	10 $\left(N \text{ telescopes}, \frac{N(N-1)}{2}\right)$
Size of telescope mirrors	3.5 m primary mirror
Spacecraft configuration	Free-flying in 3D
Length of baselines	7 to 850 m
Wavelength (λ) range	50 to 300 μm
Frequency range	1 to 6 THz
Field of view (for each telescope)	3 to 18 arcsec (frequency-dependent)
Angular resolution	0.1 arcsec (at $\lambda = 300\,\mu$m)
Telescope pointing accuracy	0.4 arcsec
Accuracy of baseline measurements	5 μm
Temperatures	80 K main dish; 4 K mixer



(a) UVW frame (b) Formation baselines

Figure 1. Illustration of the UVW reference frame and baselines.

Millimetron has ideal wavelength range for the studies of minor bodies of the Solar System

Object	*r*, a.e.	*T*, K	λ_{max}, μm
Main Belt Asteroids	1.8 – 4.2	100 – 150	20 – 30 (SACS)
Troyan Asteroids	5.1 – 5.4	100 – 125	25 – 30 (SACS)
Centaurs	5.5 – 30.1	50 – 80	40 – 60 (SACS)
Trans-Neptune Objects	> 30.1	20 – 50	60 – 150 (SACS)
Planet X	1 000	5 – 10	300 – 600 (LACS, SACS)

Observing Regimes

Surveys of selected regions

- Neighborhood of the triangular libration points in the orbits of the Earth, Mars, Jupiter, Saturn, Uranus, Neptune - it is expected that asteroids of various types will be detected, including objects coming from the Kuiper belt. Investigation of the dependence of the population of objects on the heliocentric distance. Currently, not a single object has been found in the vicinity of the triangular libration points in the orbit of Saturn. The discovery of such objects will require refinement of the models of the dynamic evolution of small bodies.
- Region of possible presence of Planet X

Observing Regimes

Observations using ephemeris

- Monitoring of Centaurs activity - searching for anomalous objects that will be inactive during the passage of the pericenter of the orbit. Currently, we have data about 491 Centaurs, which is about 1% of the expected number of Centaurs larger than 1 km in diameter.
- Selected small bodies - observations of active asteroids (about 20 such asteroids in the Main Belt are known) during phases of their activity. The discovery of new active asteroids will allow us to explore the nature of these objects, which, most likely, are not the nuclei of extinct comets. Observations of objects with anomalously large or small albedo values.
- Small bodies encounters - results of asteroid collisions are currently being observed (e.g. P/2010 A2, (6748) Gault). The expected collision rate is one collision per year. The discovery of new weak objects with the help of Millimetron will make it possible to predict the proximity of asteroids, leading to collisions.

Observing Regimes

Serendipitous discoveries

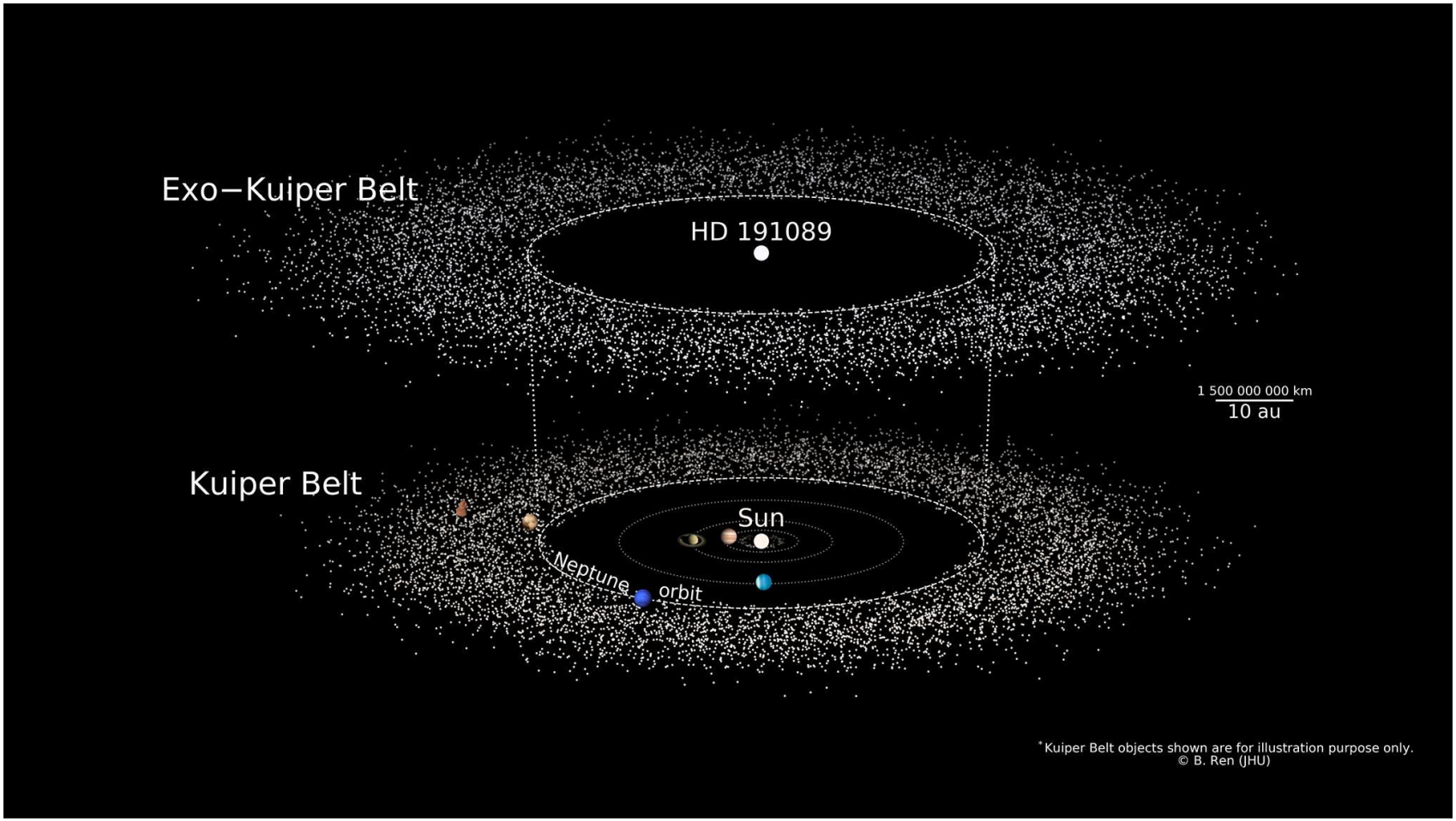
- Analysis of the images obtained in the other programs in order to identify presence of small bodies in them

This regime proved being very efficient by the NEOWISE project (Mainzer et al. 2011 ApJ 731, 53). NEOWISE has been brought out of hibernation to learn more about the population of near-Earth objects and comets that could pose an impact hazard to the Earth.

Millimetron with its better sensitivity, angular resolution and more appropriate wavelength range will be a real breakthrough in such studies.

Observing Regimes

Observations of selected extrasolar planetary systems (image from Bin Ren et al. 2019)



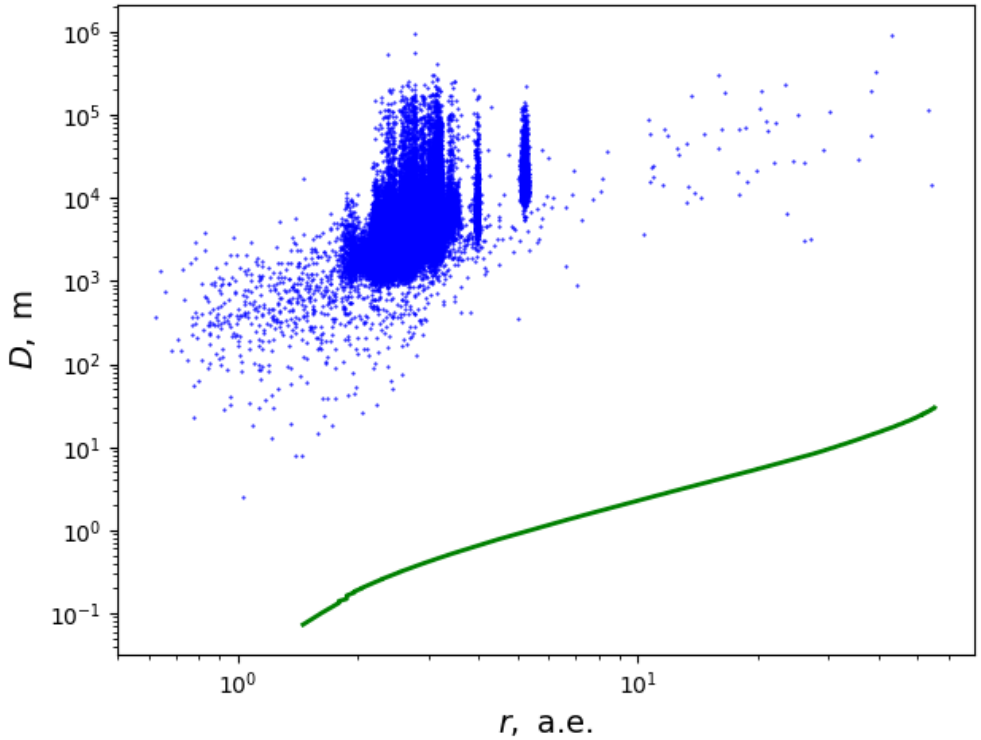
Tasks

- **Breakthrough in research of NEOs and distant minor bodies**
- **Minor bodies as the sources of the dust in the Solar System**
- **Determinations of the minor bodies physical parameters**
- **Determination of the properties of the minor bodies surfaces – basics of taxonomy studies**
- **Millimetron can make decisive contribution in the search for Planet X**
- **Studies of the minor bodies population in extrasolar systems**

r, a.e.	T, K	D, м
1.5	200	0.08
2.5	173	0.30
3.3	151	0.51
4.4	122	0.76
5.2	100	0.96
7	96	1.4
10	90	2.3
15	80	3.8
20	70	5.5
25	60	7.3
30	50	9.5
35	44	12.1
40	38	15.2
45	32	18.9
50	26	23.3
55	20	29.7
10^3	10	17360
10^3	5	$90 \cdot 10^6$
10^4	5	$905 \cdot 10^6$
10^5	3	$5 \cdot 10^{14}$

Minimal sizes of the minor bodies which can be observed with Millimetron, as a function of the distance from the Sun

Green curve shows the minimal sizes of the minor bodies which can be observed with Millimetron/
Blue points denote currently known objects with known diameters and major semi-axes



Thank you!
Спасибо за внимание!