Celestial mechanics and polarization optics of the Kordylewski dust cloud in the Earth-Moon Lagrange point L5: Imaging polarimetric new evidence for the existence of Kordylewski dust cloud

Sun

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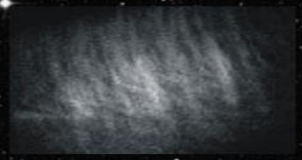
Moon



Kordylewski dust cloud

Earth

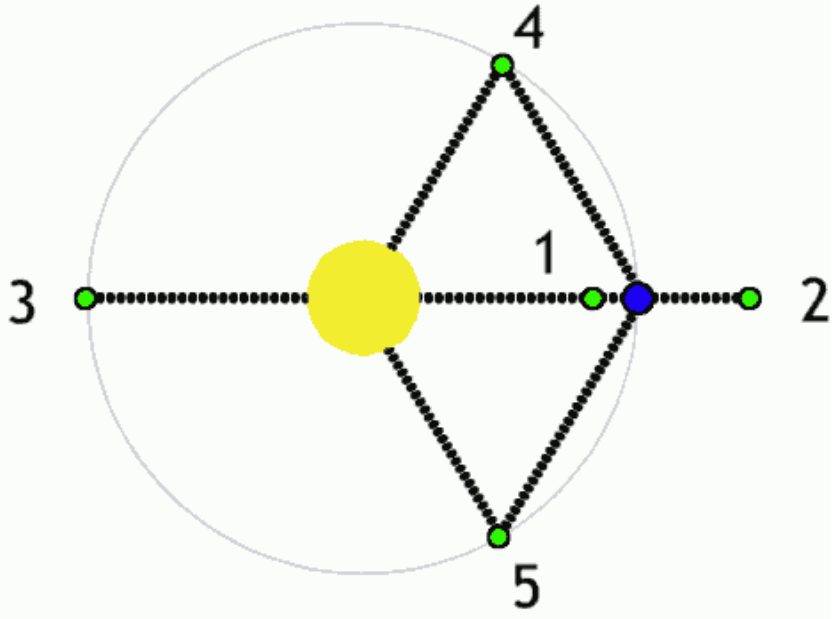
Circular planar three-body problem: Lagrange points

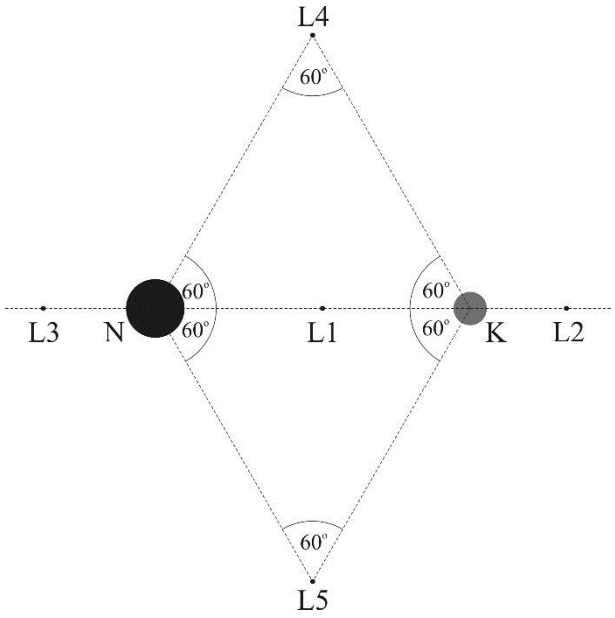
Leonhard Euler (1767):

points L1, L2, L3 are unstable

Joseph-Louis Lagrange (1772):

points L4, L5 are (un)stable





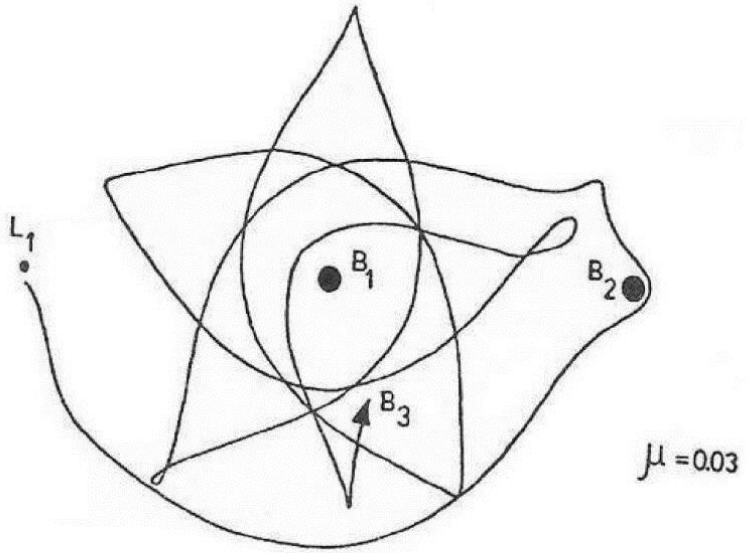
If $Q = m_{smaller}/(m_{smaller} + m_{larger}) < Q^* = 0.03852$,

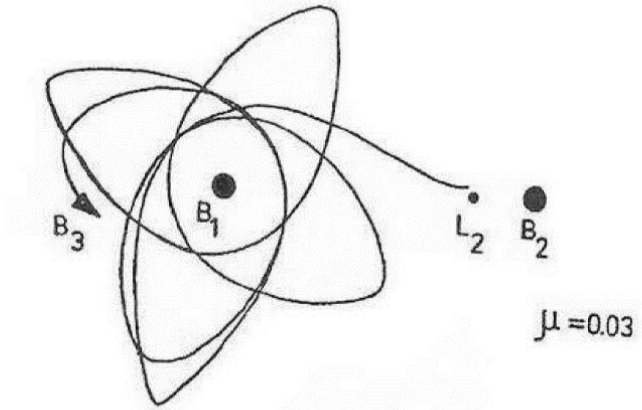
then L4 and L5 are stable.

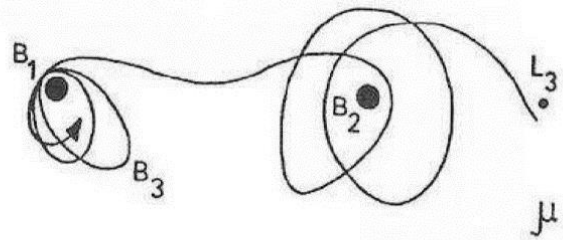
If $Q \geq Q^*$, then L4 and L5 are unstable.

$Q = m_{Moon}/(m_{Moon} + m_{Earth}) = 0.0123 < Q^* = 0.03852$,

therefore L4 and L5 of the Earth and Moon are stable.







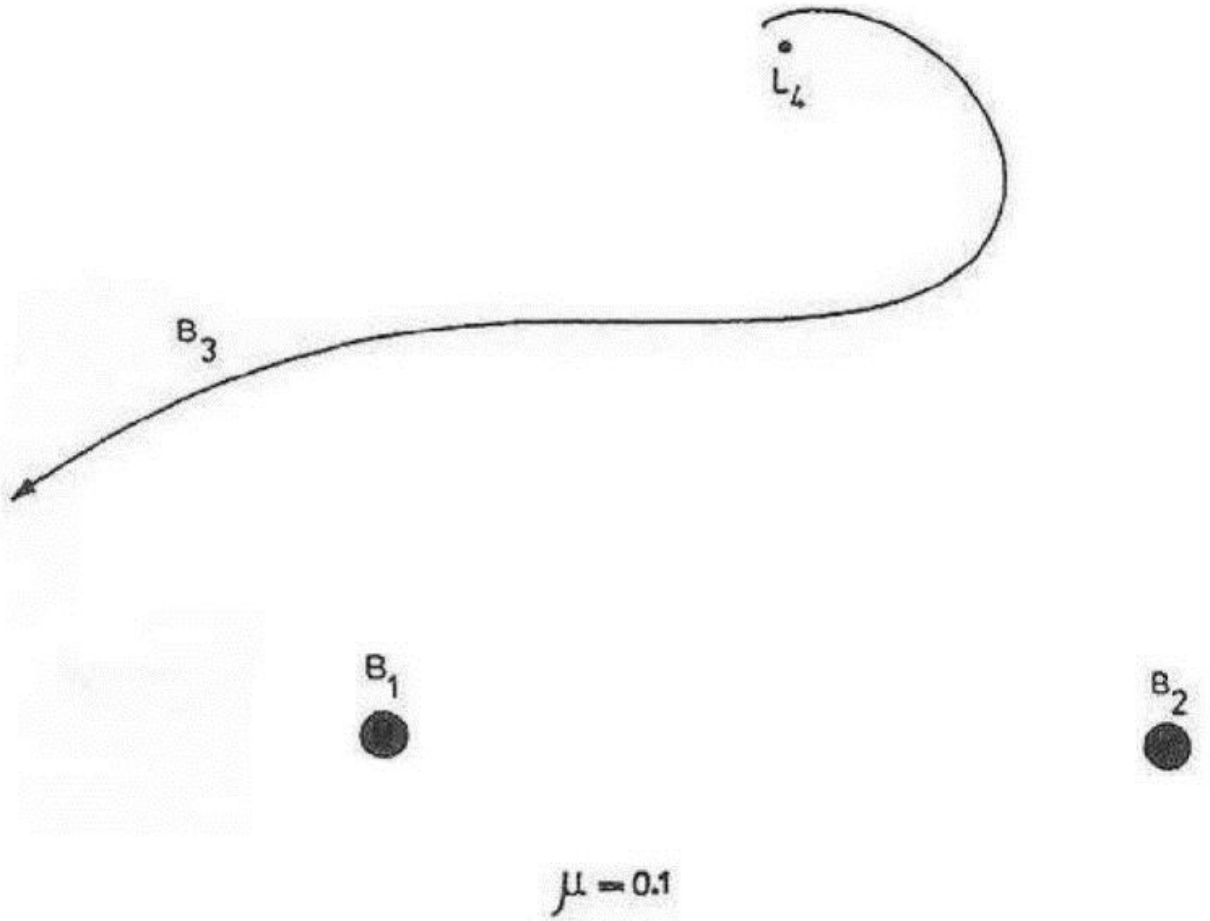
5. ábra Az instabil L_1, L_2 és L_3 Lagrange-pontok közeléből zérus kezdősebességgel indított egy-egy porrészecske pályájának kezdeti szakaszai.

Unstable L1 Lagrange point

Unstable L2 Lagrange point

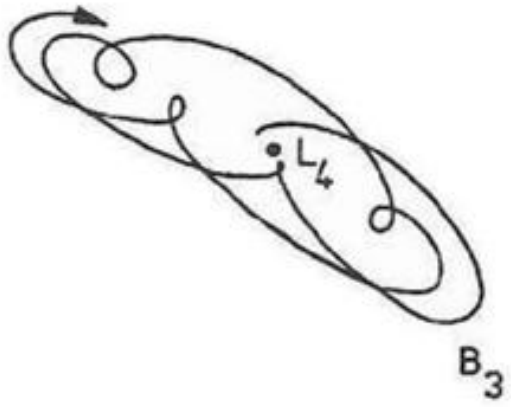
Unstable L3 Lagrange point

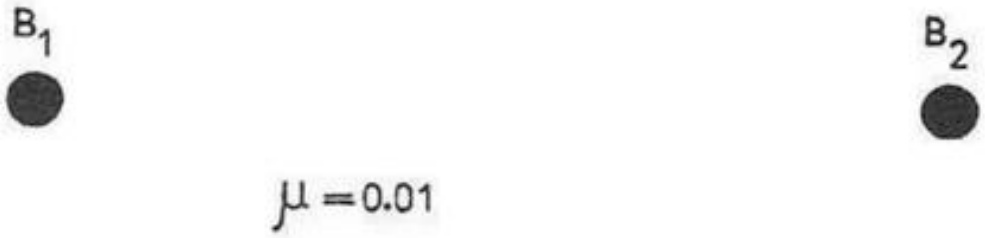
Unstable L4 Lagrange point



7. ábra A $\mu > \mu_o$ választással instabillá tett L_4 Lagrange-féle librációs pont közeléből, a *6. ábra* kezdő- és peremfeltételeivel megegyezően induló porrészecske pályájának kezdeti szakasza.

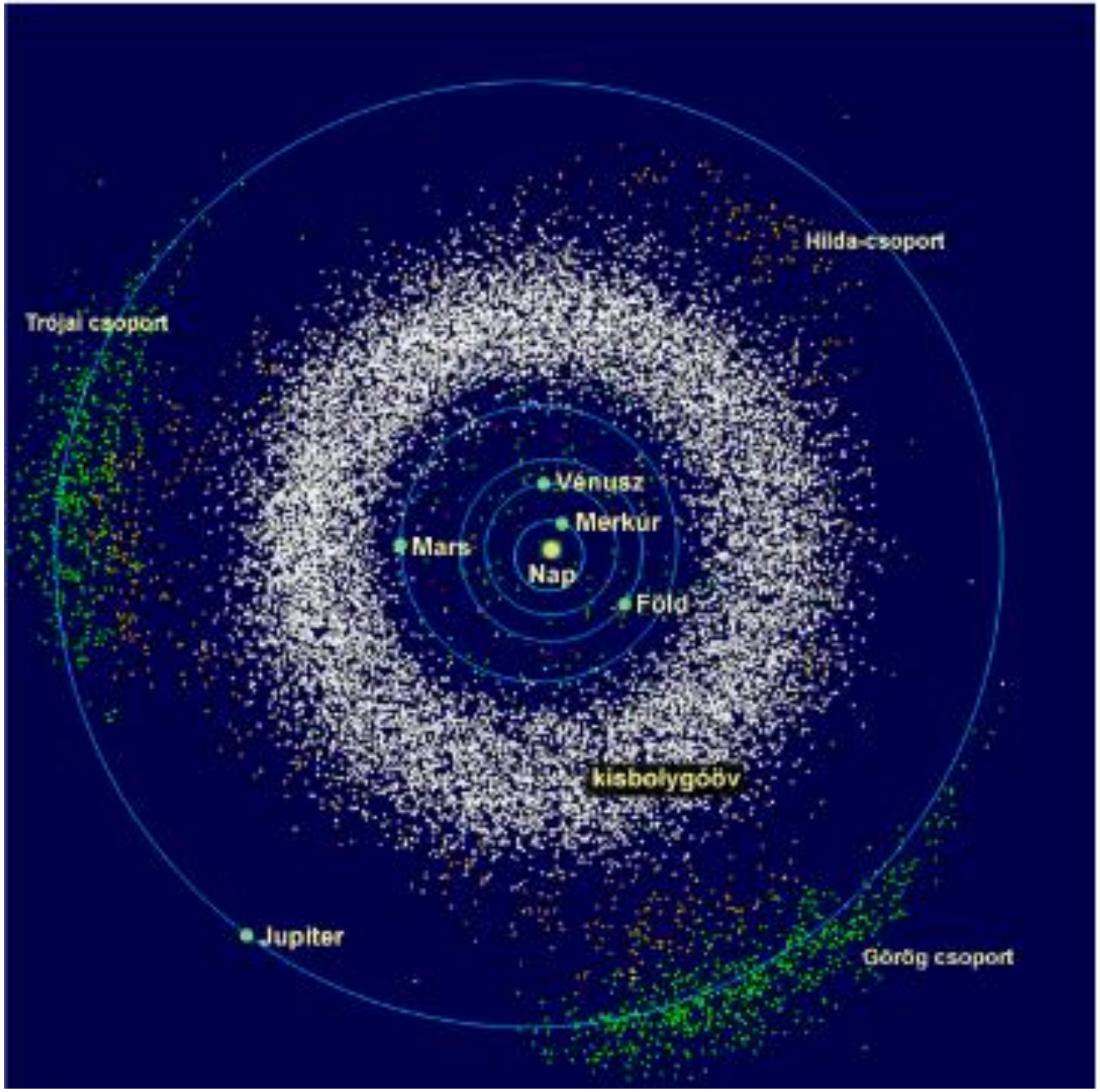
Stable L4 Lagrange point





6. ábra A $\mu < \mu_0$ választással stabillá tett L_4 Lagrange-féle librációs pont közeléből nulla kezdősebességgel induló porrészecske hurkokból álló librációs pályájának kezdeti szakasza.

Asteroids in the stable L4 and L5 points of the Solar system



Asteroids around the L4 and L5 points:

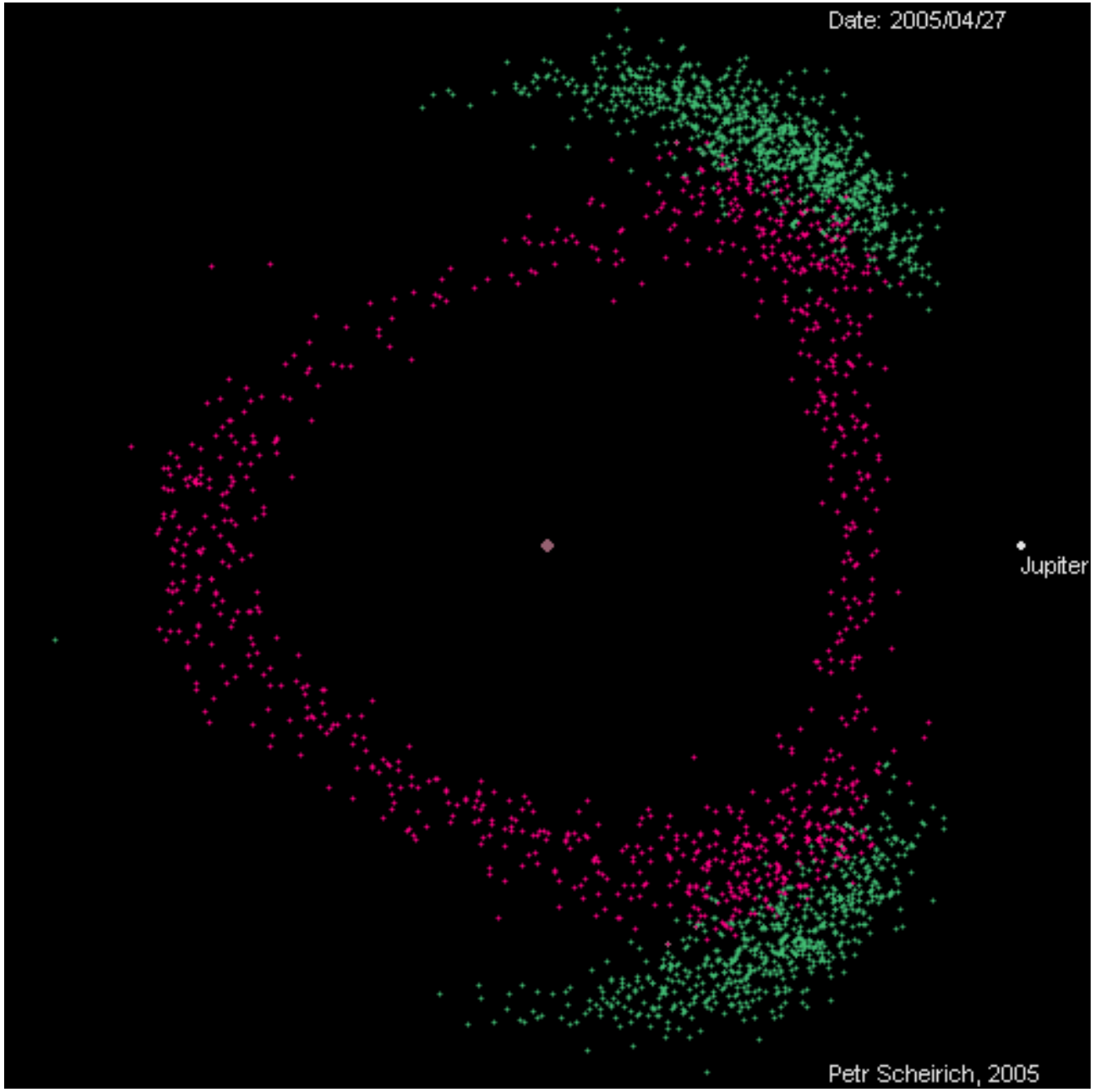
Jupiter - Sun
(L4, L5 : many thousands asteroids)

Mars - Sun
(L4: 1 asteroid,
L5: 3 asteroids)

Neptune - Sun
(L4: 6 asteroids,
L5: 1 asteroid)

Earth - Moon
(L5: 1 dust cloud ?)

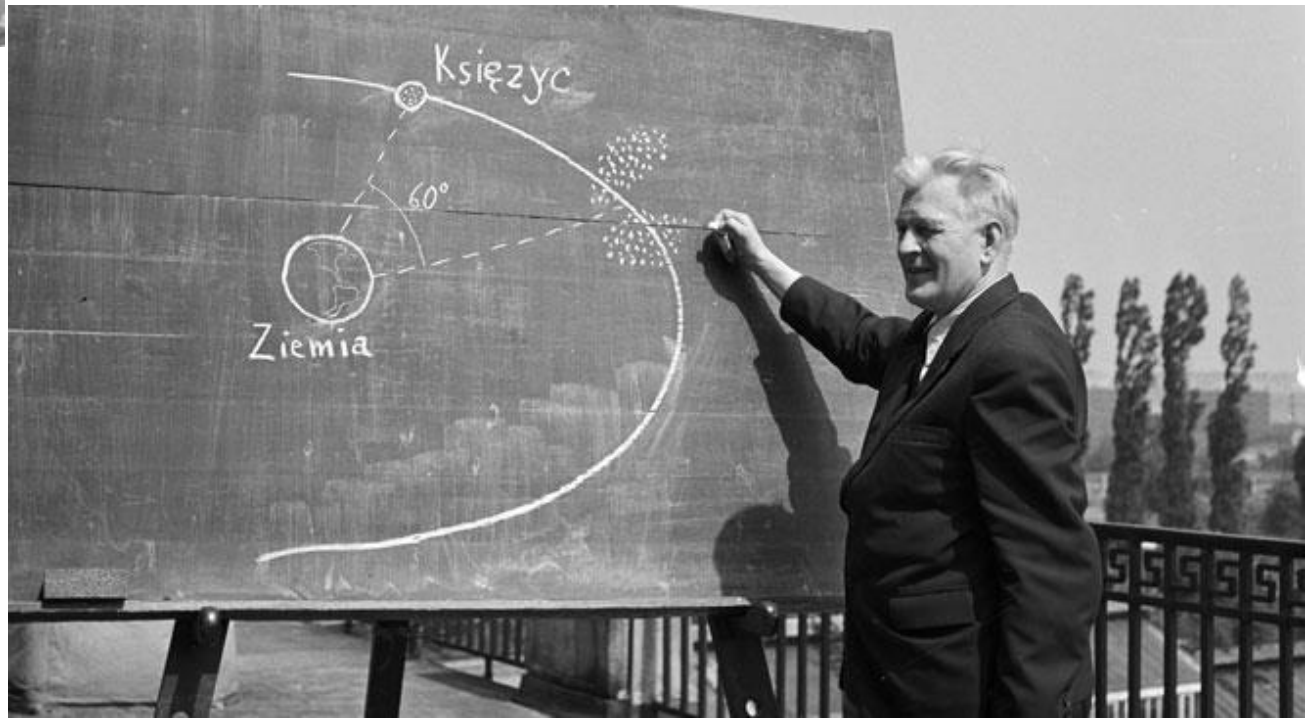
Simulated particles of the Sun-Jupiter system in a co-rotating coordinate system



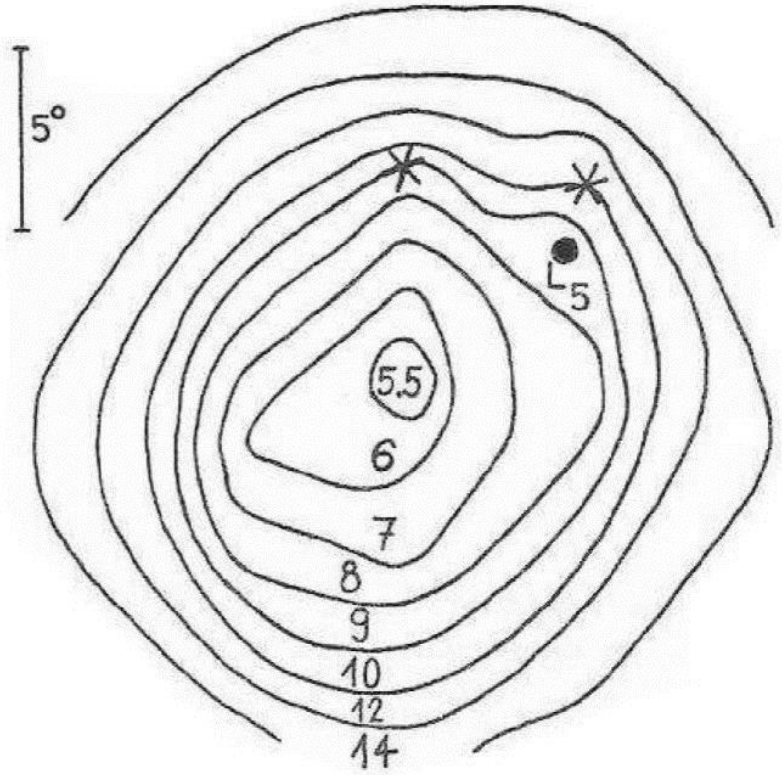
Kazimierz Kordylewski (1903 - 1981)

L4 and L5 points of the Earth-Moon system are stable –> dust clouds ?

Kazimierz Kordylewski in Krakow, 1961



Photometric detection of the dust cloud by Kazimierz Kordylewski in 1961



3. ábra Az állandó fényintenzitáshoz tartozó görbék serege ([8] alapján) a Föld-Hold rendszerben. Az egyes görbékhez tartozó számok a fényintenzitást mutatják magnitúdóban. Az L_5 librációs pont az ún. ellenfény közelében van, s ez az ellenfény okozza a központi kifényesedést. Jól látható az L_5 stabil librációs pont körüli két kidudorodás a görbeseregben, ami a környezetnél nagyobb fényintenzitás miatt a bolygóközi por helyi sűrűsödésére utal. Elsőnek Kordylewski azonosította ezt a két sűrűsödési gócot a Föld porholdjaiként.

Earlier attempts to detect the Kordylewski dust cloud (KDC) around the L5 point

NASA (1966): found the KDC with naked-eye observations from an airplane

Roosen (1966, 1968): did not find the KDC by photography

Wolff (1967): did not find the KDC by photography from an airplane

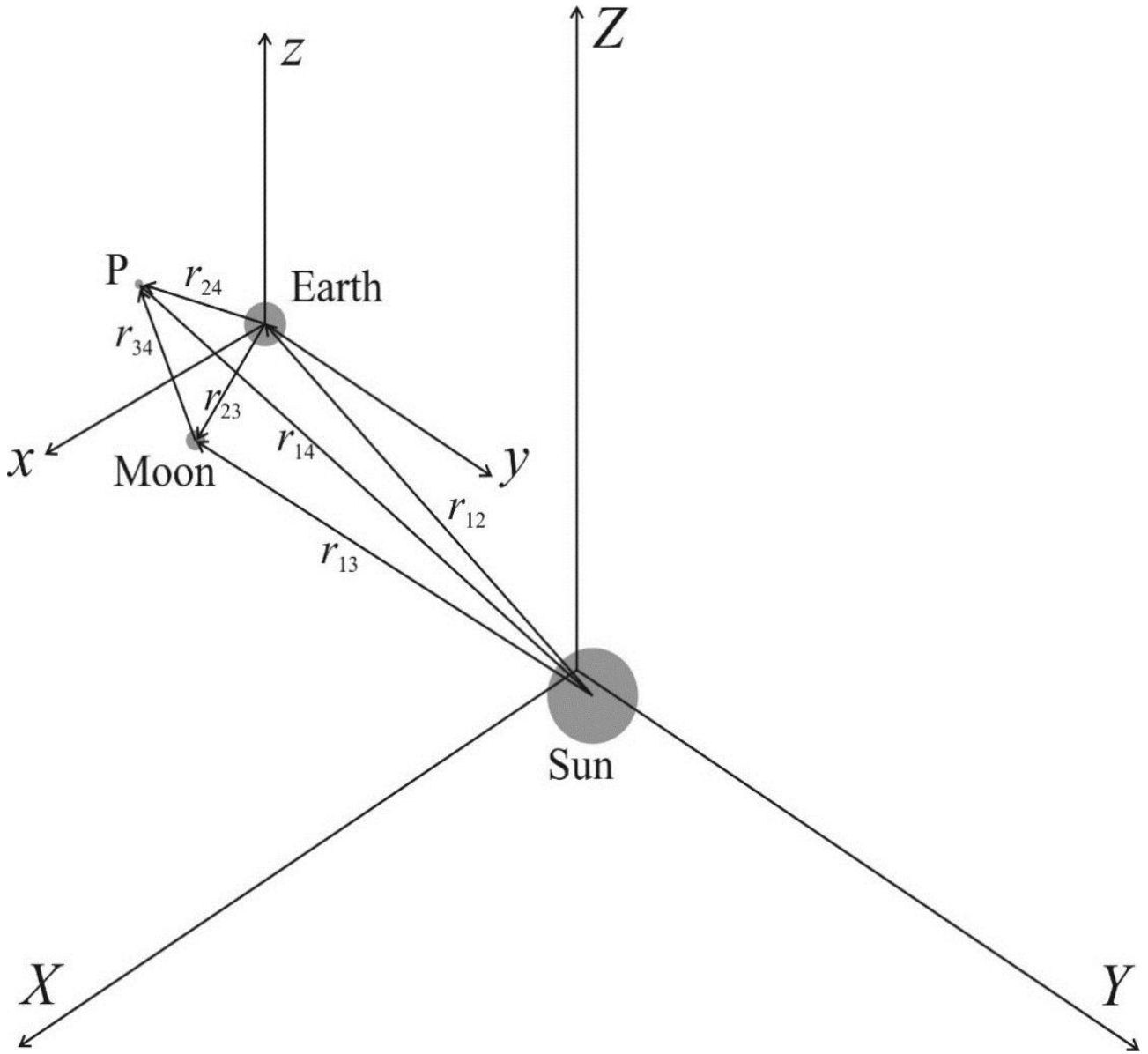
Roach (1975): found the KDC with an angular diameter of 6^{o}

Valdes & Freitas (1983): found nothing by photography

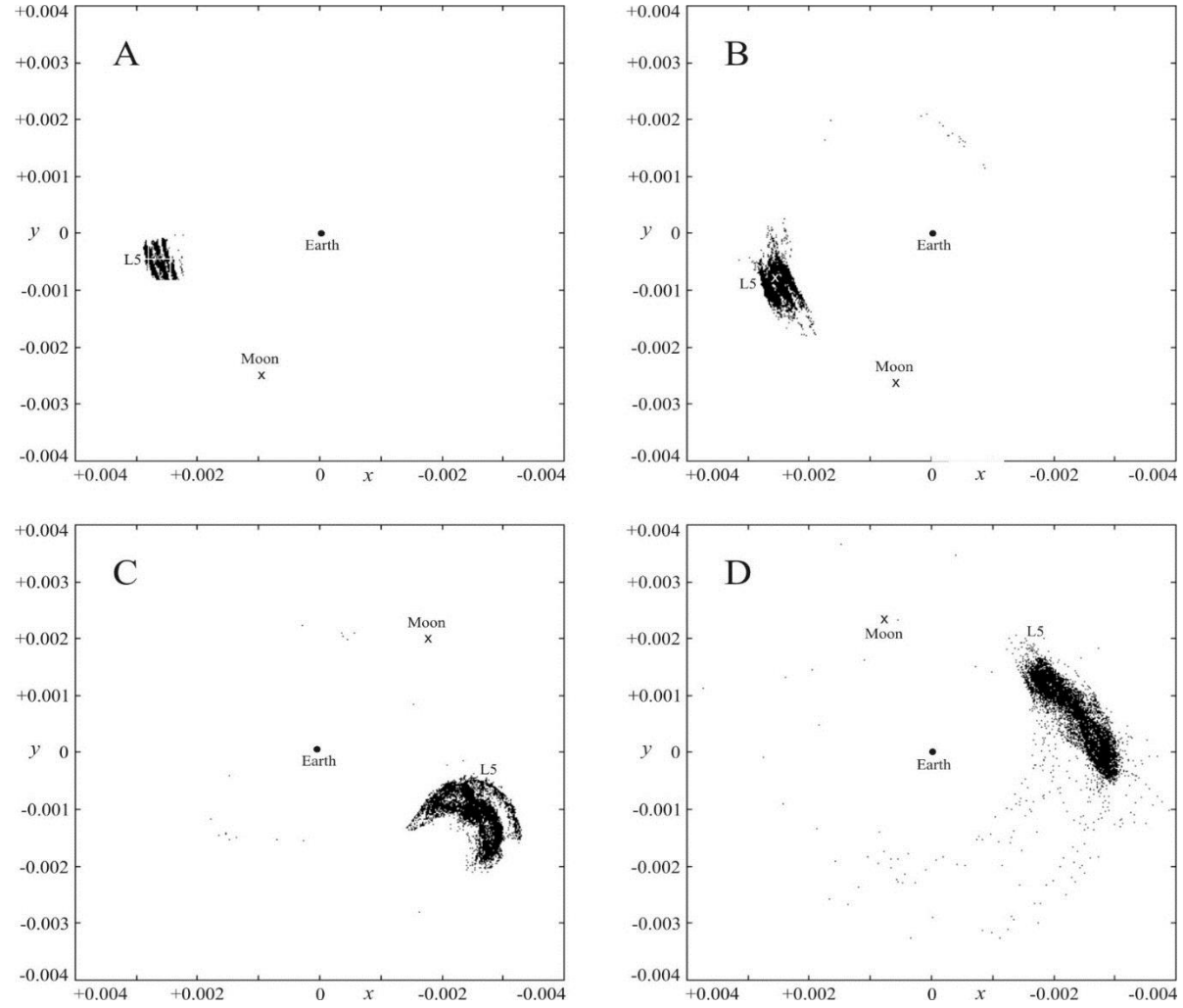
Winiarski (1989): observed the KDC by telescope

Japanese HITEN satelite (1992): did not find particle aggregation

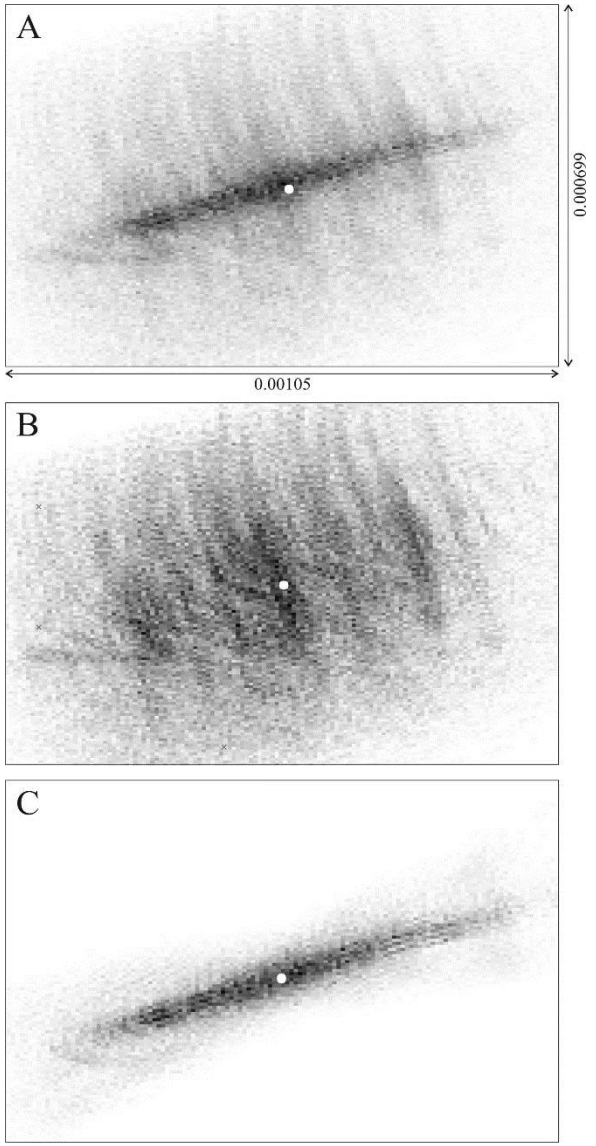
Computer modelling of dust cloud formation around the L4 and L5 points of the Earth-Moon system with 1 860 000 particles and the Sun in 3 dimensions



Evolution of the computer-modelled Kordylewski dust cloud in 3 dimensions for 10 years



Density of the Kordylewski dust cloud simulated around the L5 point of the Earth-Moon system versus time for 1 860 000 particles



Evolution of simulated dust clouds around the L4 and L5 points of the Earth-Moon system

Video clip

Astronomical observatory of Judit Slíz-Balogh in Balatontördemic

FORNAX 100 mechanics

MEADE 16" f/10 ACF

GPU 132/1050

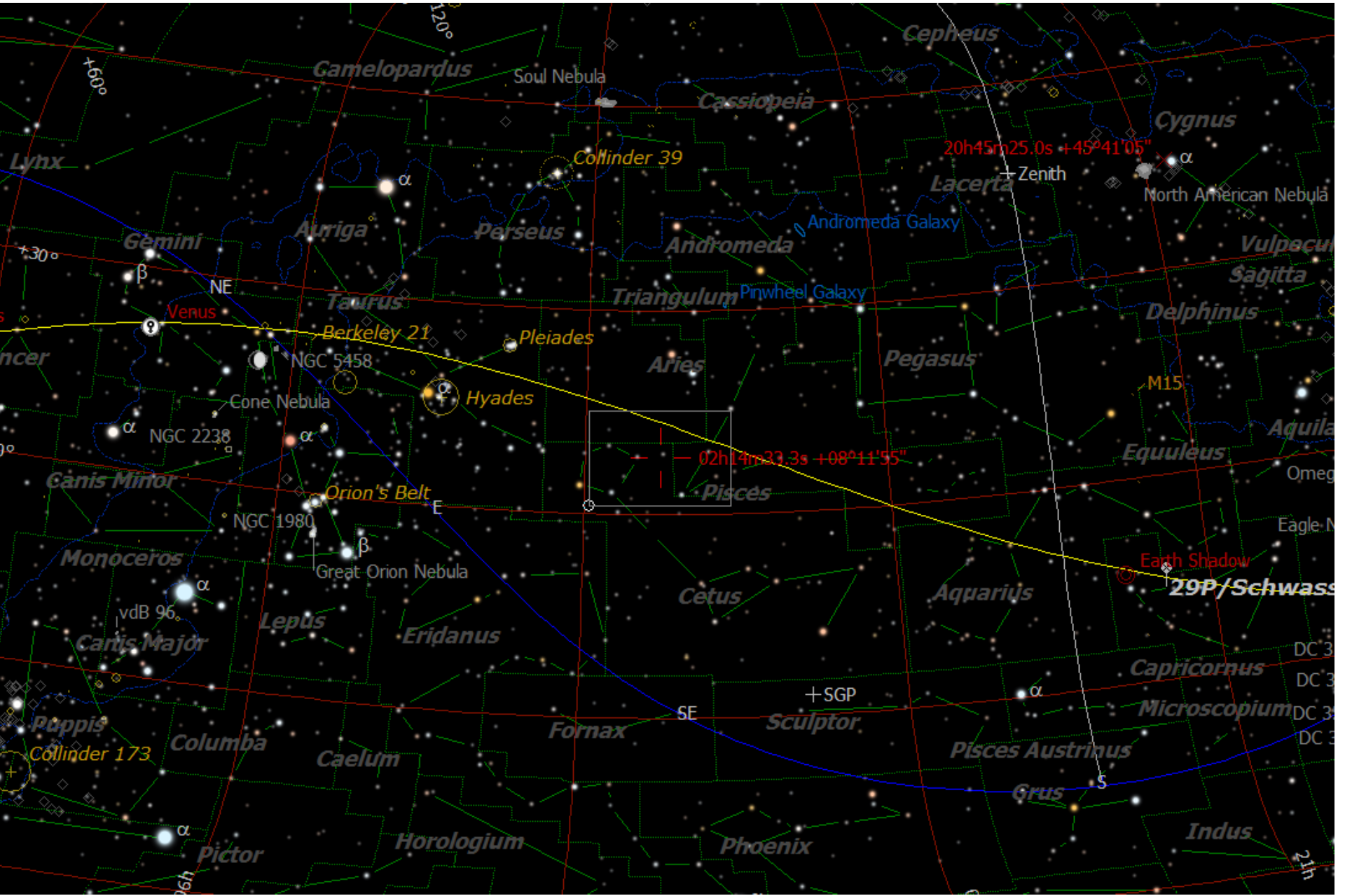
Tokina AF 300/2.8 teleobjective

Samyang T3/100 teleobjective

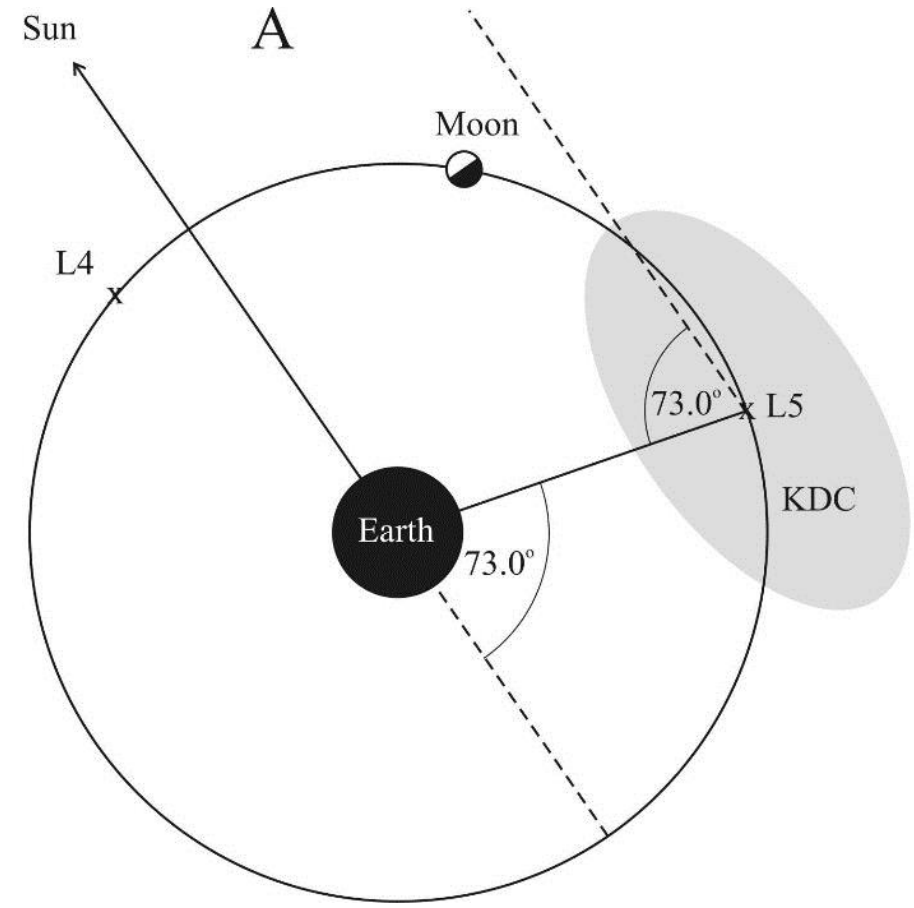
Moravian G3-11000 ABG CCD

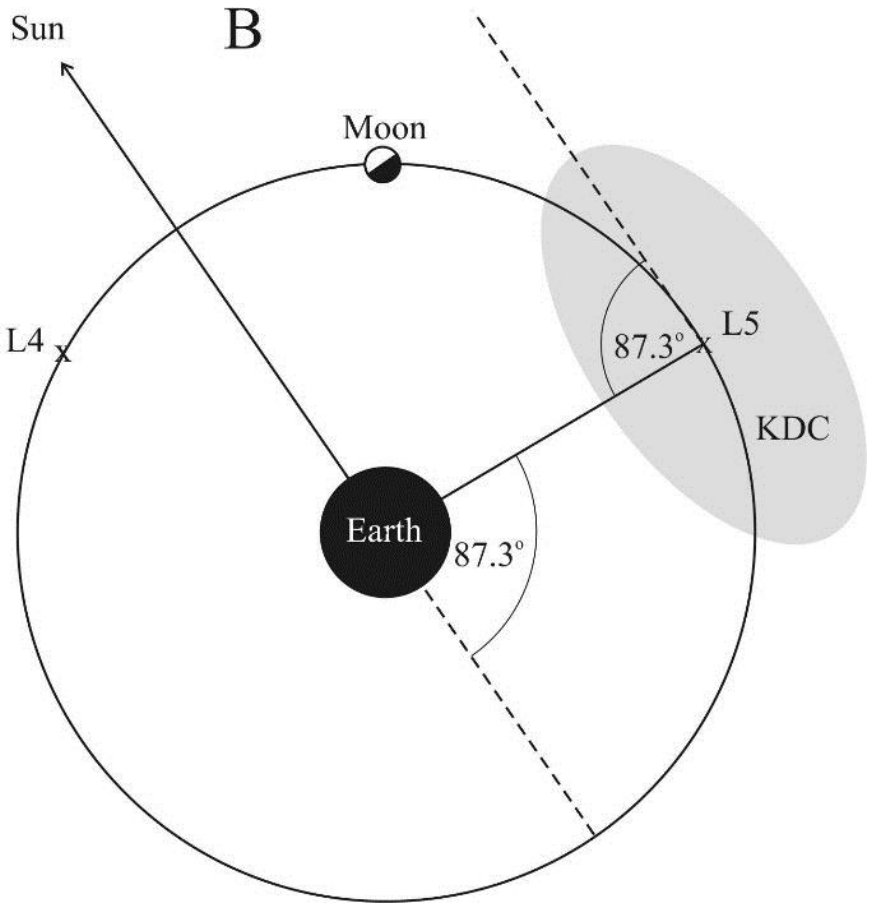
Judit Slíz-Balogh

Position of the L5 point of the Earth-Moon system: 23:29:67 UT, 17 August 2017

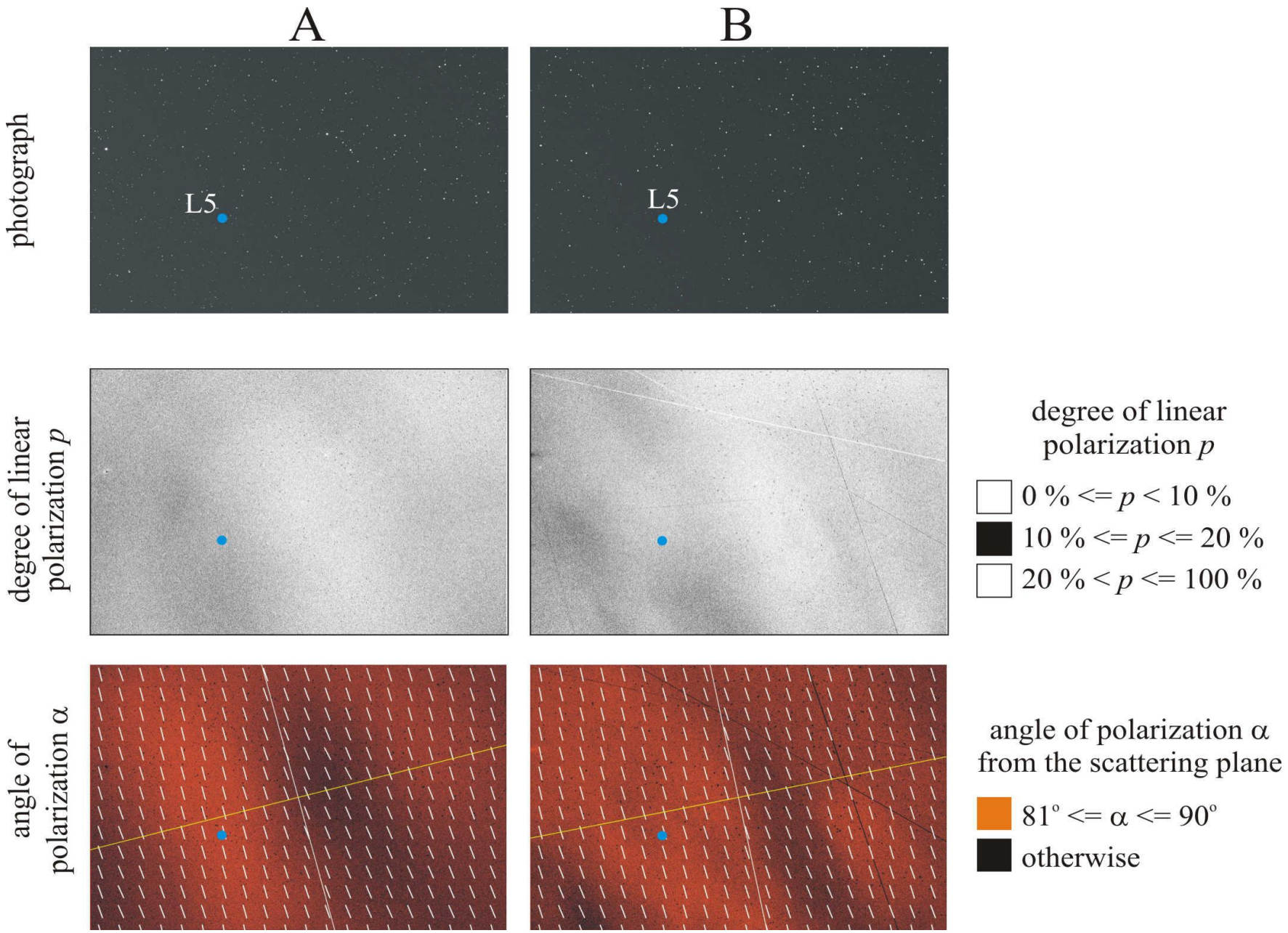


The Kordylewski dust cloud in the L5 Lagrange point of the Earth and Moon detected by imaging polarimetry (A) on 17 August (23:29:67 UT) and (B) on 19 August (01:14:15 UT) 2017

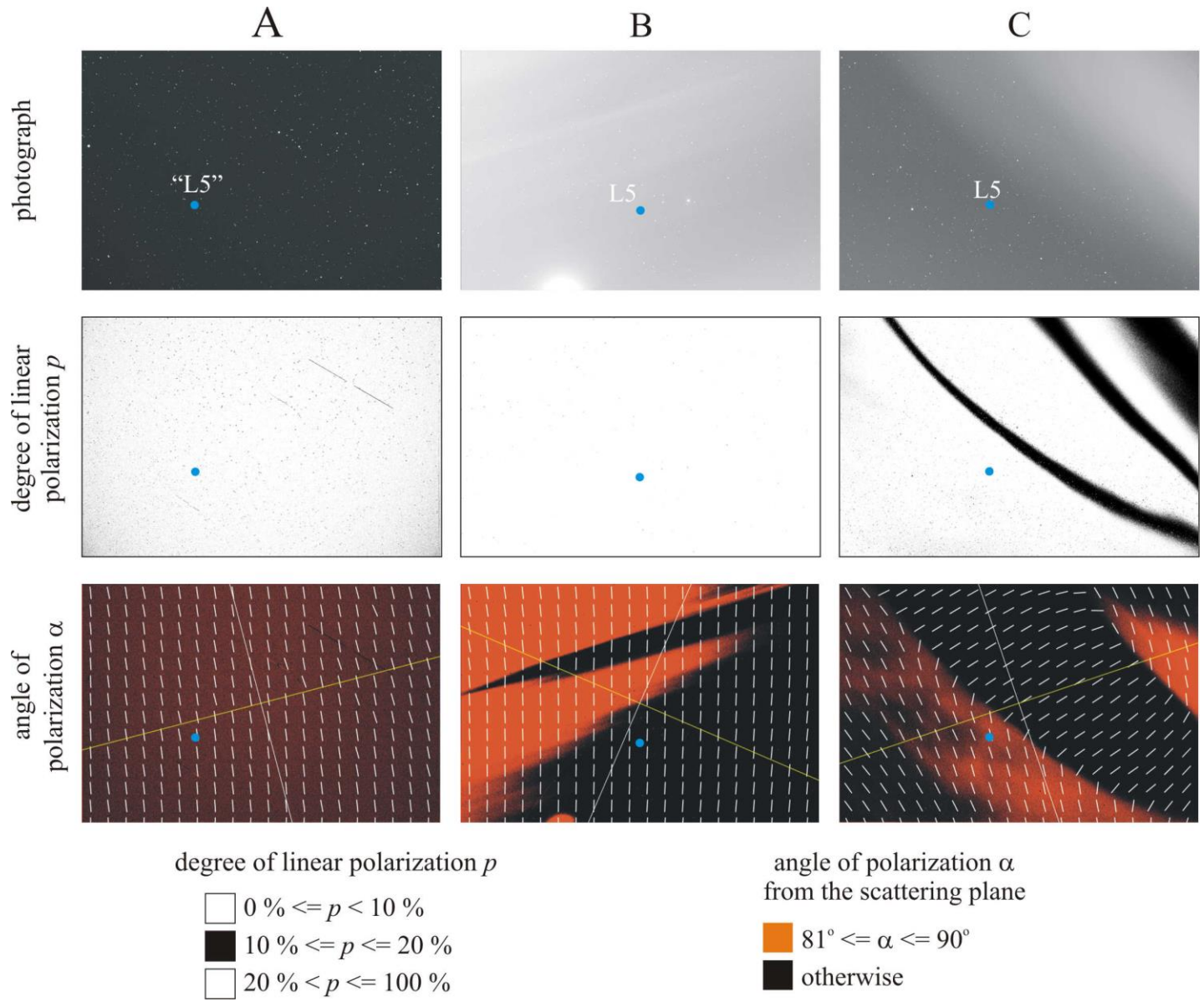




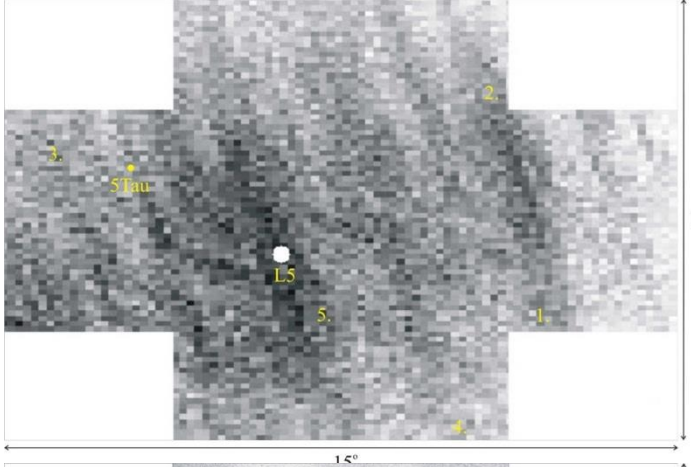
Imaging polarimetry of the Kordylewski dust cloud on 17 and 19 August 2017



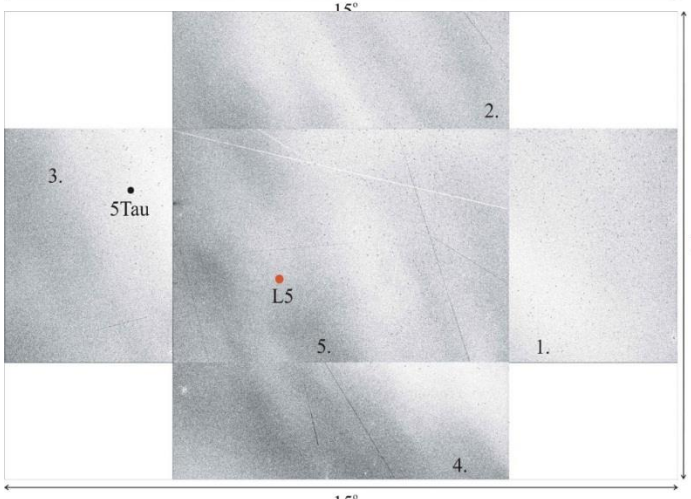
Control measurements:
(A) without L5, but with zodiacal light (sunlight scattered by zodiacal dust in the Ecliptic), (B) cirrus cloud, (C) condensation trail of an airplain



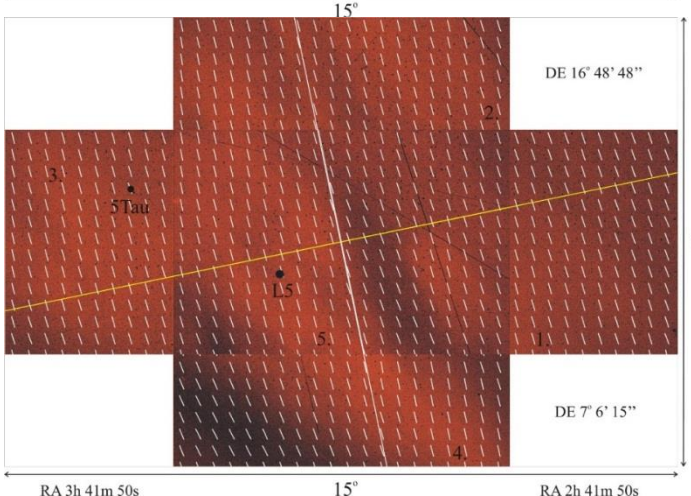
Patterns of the Kordylewski dust cloud



Computer modelling



Degree of linear polarization



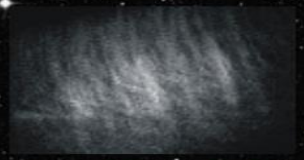
Angle of polarization

Position of the simulated Kordylewski dust cloud at 01:14 UT on 19 August 2017

Sun

Thank you for your attention!

Moon



Kordylewski dust cloud

Earth