Kordylewski clouds: the observational object for the most ambitious.

Tomasz Mrozek

1. Astronomical Institute, University of Wrocław
2. Solar Physics Division, Space Research Centre, Polish Academy of Sciences
Tycho Brahe carried out extremely accurate visual observations. Their accuracy has allowed Kepler to formulate three laws of planetary motion.

but...

These laws only described observations. There was no theory. There was no physics that could explain them.

until...

Isaac Newton
June 5th, 1686, *Philosophiae Naturalis Principia Mathematica* is published.

“I deduced that the forces which keep the planets in their orbs must [be] reciprocally as the squares of their distances from the centers about which they revolve: and thereby compared the force requisite to keep the Moon in her Orb with the force of gravity at the surface of the Earth; and found them answer pretty nearly.”

\[ F = G \frac{m_1 m_2}{r^2} \]

Since then, Kepler's laws were justified physically and the rapid development of analytical methods for the study the motion of planets and other objects in the solar system took place.
A bit of history

Laws of motion given by Newton made it possible to solve analytically two-body problem.

but...
The three body problem was not solved. Only constant-pattern solutions were found.

Joseph-Louis Lagrange

Laws of motion given by Newton made it possible to solve analytically two-body problem.
A bit of history

Those solutions were later seen to explain what are now known as the Lagrangian points.

In the rotating system of two bodies, there are five points of equilibrium.

The body of a very low mass is stable at such point.
A bit of history

In 1906, Max Wolf discovered asteroid 588 Achilles stable object in Lagrangian L4 point.

Currently, we know more than 4500 similar objects found in the system of the Sun and: Mars – 4, Saturn – 4, Neptune - 7.
In 1951 prof. Banachiewicz ordered to develop a program observation utilizing unused double astrograph.

The program was developed by Dr. Kazimierz Kordylewski. He wanted to look for objects in Lagrangian points of the Earth – Moon system.

Kordylewski expected that hypothetical objects should have a brightness about 12 mag.
Kordylewski did not find the desired object, but prof. Witkowski suggested that in the Earth-Moon system only dust may be gravitationally bound.

Kordylewski began to make photographs of selected areas of the sky with the camera with a bright lens, but he was defeated again.

He decided to start visual observations.
The discovery

Observations were carried out in high Tatra at the tops of Łomnica (2634 m) and Kasprowy Wierch (1987 m)

The first observation - October 1956. Two days later, Dr. Kordylewski observed cloud again and concluded that shift of cloud is consistent with movement of the Moon.

In 1961 (March and April) the photographs were taken – Kordylewski was ready to publish his results


Photographische Untersuchungen des Librationspunktes L5 im System Erde-Mond
Doubts and confirmation

Many observers trying to repeat observations but failed.

For Kordylewski it is not surprising simply because it is a difficult task that took him 10 years of hard work...

But finally...

First confirmation came

---

J. Welden Simpson is founder and director of the Lick Observatory at Lockheed-Martin + Space Co.

Simpson 1967
## Properties

<table>
<thead>
<tr>
<th>Reference</th>
<th>Date</th>
<th>Technique</th>
<th>Magnitude (arcsec²)</th>
<th>Cloud size</th>
<th>Number density enhancement</th>
<th>Col. density (cm⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grün et al. 1985</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5°</td>
<td>-</td>
<td>~10⁻³</td>
</tr>
<tr>
<td>Kordykweski 1961</td>
<td>March - April 1961</td>
<td>Photographic (35mm film, 50mm focal length, f/1.5, 12 min. exp.)</td>
<td>22</td>
<td>5°</td>
<td>1.2 x 10⁵</td>
<td>2.0 x 10¹</td>
</tr>
<tr>
<td>Simpson 1967</td>
<td>January 1964, February 1966, March 1966</td>
<td>Visual, Photographic (4-8 min exp.), Visual (airborne)</td>
<td>20.5</td>
<td>4°</td>
<td>6.0 x 10⁵</td>
<td>6.8 x 10¹</td>
</tr>
<tr>
<td>Vanysek 1969</td>
<td>March 1966</td>
<td>Visual (airborne)</td>
<td>22.6</td>
<td>4°</td>
<td>8.9 x 10⁴</td>
<td>1.0 x 10²</td>
</tr>
<tr>
<td>Roosen 1968</td>
<td>March 1966, March 1967</td>
<td>Photographic (35mm film, 50mm focal length, f/1.4, 1-9 min. exp.)</td>
<td>fainter than 26</td>
<td></td>
<td>&lt;2°</td>
<td>&lt;8.0 x 10³</td>
</tr>
<tr>
<td>Wolff et al. 1967</td>
<td>March 1967</td>
<td>Photographic (airborne, 35mm film, 50mm focal length, f/1.4, 20-40 min. exp.)</td>
<td>fainter than 25.4</td>
<td>4°</td>
<td>&lt;2°</td>
<td>&lt;1.4 x 10⁴</td>
</tr>
<tr>
<td>Roach 1975</td>
<td>Autumn 1969 to Winter 1970</td>
<td>Photometric: Rutgers Zodiacal Light Analyser on OSO-6</td>
<td>24.5</td>
<td>6°</td>
<td>1.0 x 10⁴</td>
<td>21</td>
</tr>
<tr>
<td>Schlosser et al. 1975</td>
<td>March to April 1971</td>
<td>Photographic: using wide angle (140°) photographs.</td>
<td>fainter than 26.6</td>
<td></td>
<td>&lt;7°</td>
<td>&lt;1.3 x 10³</td>
</tr>
<tr>
<td>Munro et al. 1975</td>
<td>July to December 1973</td>
<td>Photometric (white light coronograph on Skylab)</td>
<td>fainter than 16.7</td>
<td></td>
<td>&lt;5°</td>
<td>&lt;1.2 x 10³</td>
</tr>
<tr>
<td>Winarski 1989</td>
<td>February 1976</td>
<td>Photographic: various techniques</td>
<td>23.8</td>
<td>2°</td>
<td>2.2 x 10⁴</td>
<td>30</td>
</tr>
</tbody>
</table>

Moeed i Zanecki 1997
Let us try!

More than 50 years after the first observation the existence is still disputed by some researchers.

Nevertheless, the problem is waiting for a solution.

This could be an interesting problem for amateur astronomers under the darkest sky.
Let us try!

Laufer R. et al. 2010, THE KORDYLEWSKY CLOUDS – AN EXAMPLE FOR A CRUISE PHASE OBSERVATION DURING THE LUNAR MISSION BW1:

- the libration clouds are about 6 degrees in angular size as seen from the Earth,
- they move around the libration point, over an elliptical zone with a semi-major axis of about 6 degrees along the ecliptic and a semi-minor axis of about 2 degrees perpendicular to the ecliptic,
- the libration clouds are closer to the Moon during the northern summer months, and away from the Moon during the northern winter months with respect to the Lagrangian point,
- brightness is about half the brightness of the counterglow,
- color is much redder than the counterglow,
- this might indicate that the particles are of a different nature as in the counterglow.
- they are transient events...
Thank you for your attention