Possibility of the Near Earth objects distance measurement with laser ranging device

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Fig. 1. Measurements of minor planets with laser ranging device
\[ d_{la} = 2 \cdot L \cdot \tan r_d \]  \hspace{1cm} (1)

where \( r_d \) is the diffraction, the angle radius \( r_d = 1.2197 \lambda / dt \)

As the energy li diffraction image is irregular, the energy radiated in the direction of the minor planet Eep can be calculated using formula:

\[ E_{ep} = E_{las} \cdot c_{at} \cdot c_{op} \frac{\int_{r_i}^{r_{i/2}} l_i(r) \cdot r \cdot dr}{\int_{0}^{r_i} l_i(r) \cdot r \cdot dr} \]  \hspace{1cm} (2)

\( E_{las} \) – laser emanated energy;
\( c_{at} \) – light transmissivity of the atmosphere;
\( c_{op} \) – light transmissivity of the optical system;
\( d \) – diameter of the minor planet
The surface of the minor planet is matted and its each element reflects the light in 
accordance with the Lambert Law. Area S on the Earth receives radiated energy \( E_e \):

\[
E_e = E_p \cdot c_{at} \cdot a \cdot \cos i \cdot S/\pi L
\]  \hspace{1cm} (3)

\( i \) – mean surface normal angle turned in the direction of the Earth;
\( a \) – reflection coefficient (albedo).

As \( E_e \) is very weak, the reflected energy can be described with the number of photons 
per unit of area \( n_f = E_e/E_{fot} \), where \( E_{fot} \) – photon energy:

\[
E_{fot} = h \cdot \nu
\]  \hspace{1cm} (4)

\( h \) – Planck’s constant \((h = 6.622 \cdot 10^{-34} \text{ J} \cdot \text{s})\);
\( \nu \) – frequency of light wavelength.
laser energy = 10 J
laser wavelength = 0.694 mkm
laser beam divergence = 0.5819907 " (2 r difr)
atmospheric transmittance = 0.8
quantum effect = 50 %
planets albedo = 10 % (black)

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<th>minor planets diameter m</th>
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<th>200</th>
<th>400</th>
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</table>

Table 1. Reflected photons from minor planet.
Minor planet 2002 NY 40  L=400000 km  D=0.2 km

photon 79706 on 1km^2, 11 laser shot, rec. photons 2, telescope 2.6 m

Fig. 2. Photons rain on Earth surface
Fig. 3. Reflected laser pulses and noise from minor planet.
Fig. 4. The laser arrangement relative to the telescope
Fig. 6. Real laser energy distribution in the far zone

Laser beam D = 20 mm
las. diverg = 10 ″

las. diverg = 30 ″

β_y = 0°
β_z = 0°
by = 0 ″
bz = 0 ″
Fig. 9. Spectrograph for receiving laser pulses
Fig. 11. Spectrograph for reflected pulses measurement
A possible arrangement of transmitting and receiving telescopes for NEO distance measurements
630 mm paraboloid mirror
The telescope model
Forecasted trajectories of asteroid 500 days after observation

angular coordinates error = .5 ''
no range measurements
no velocity measurements

Planets rectangular coordinates error after 500 days
eps X = 2612101 km
eps Y = 280573.3 km
eps Z = 164294.8 km
angular coordinates error = 0.5 '
range measurements error = 10 m
no velocity measurements
Planets rectangular coordinates error after 500 days
eps X = 1596.051 km
eps Y = 366.4737 km
eps Z = 385.6769 km
This project can be carried out in co-operation with other astronomers of the Baltic States. Its implementation would enable scientists to improve significantly the orbital elements of the minor planets that present danger to the Earth and to forecast their motion in the future.
Thank You for attention