The objective of the proposed research and reasons for choosing the research topic

The overall objective of the proposed research is to answer the questions about the origin of the observed near-parabolic comets. We're going purely observational way in which the basis for proposed studies are positional observations of long-period comets (hereafter LPCs) discovered so far. This approach requires very precise methods of orbit determination of each individual comet under study (i.e. osculating orbit which represents a given set of positional observations). Another words, we aim at gathering a collection (as large as possible) of the precise osculating orbits of LPCs, which allow us to investigate the apparent source and the origin of these comets. Therefore, we follow the dynamical evolution of each comet for typically a few-several million years1, influenced initially by the action of planetary perturbations, and next by the gravitational perturbation from the neighboring stars and the full gravitational field of our Galaxy. The main subject of our interest is a large group of so-called 'Oort spike' comets, i.e. comets with original semi-major axes greater than 10 000 AU, observed well enough to be sure that their orbit determination is fully reliable.

The novelty of the project do not come from the unique subject – this issue (i.e. the apparent source and origin of LPCs) bother scientists for centuries, however, the way we approach this problem is unique. We offer much more sophisticated and precise methods of data treating, non-gravitational (hereafter NG) orbit determination when it is possible, sometimes even with a dedicated form of NG acceleration. Furthermore, we strictly take into account all known factors affecting motion of the near-parabolic comet as well inside our Solar System and in its Galactic neighbourhood. Every year several near-parabolic comets are discovered, thus – even from this perspective alone - determining their precise orbits is a very timely research.

The problem of the apparent source and the origin of long-period comets still waits for its definitive answer. All computer simulations of the Solar System origins do have many problems in reproducing observable characteristics of populations of small bodies, asteroids, comets, Kuiper Belt objects etc. In other words, populations of small bodies have now become crucial in the verification scenarios for the evolution of the solar system.

These simulations are prepared (among others) on the basis of the characteristics of currently observed long-period comets. We insist, that lots of LPCs orbits should be recalculated. Major improvements should include incorporation of NG forces (where possible), resulting from asymmetric sublimation of volatiles from the cometary nuclei surface. Individual, tailored approach at every stage of orbit determination seems to be necessary also.

The existence of the Oort Cloud, huge, spherically symmetric reservoir of protocomets at a distance comparable with the half of that to the closest star still do not posses any direct observational support. Since the beginning of this hypothesis the main argument is the distribution of energies of the observed long period comets. It's maximum at the semimajor axis of 30 – 50 thousands of AU is often treated as the “sender address”. We postulate, that using only the observed semimajor axis is not sufficient to discriminate between dynamically new comets (entering the planetary system for the first time) and the old ones.

Moreover, the omission of nongravitational forces may lead to false values of the semimajor axis. From our results obtained so far, we can conclude, that as much as 50% of the observed long period comets might have visited the inner planetary system during their previous apparition. As a results their orbits should be excluded from the investigation of the apparent source of these comets. Deep insight into the dynamical history of all observed long-period comets seems to necessary if we want to describe their source and origin. In addition, more than half of the investigated 'Oort spike' comets seems to leak out of the solar system, thus it is not clear how the current (observed) distribution of the original inverse semimajor axis distribution is stable.

Long-period comets are widely treated as the most primitive bodies, witnesses of the early stages of the Solar System formation. From that point of view studying their dynamics helps us to fully understand the role of small bodies populations in forming our planetary system. An increasing knowledge on the origins of our Solar System is in turn very helpful in contemporary attempts to understand a variety of different extrasolar planetary systems we discover nowadays in a great number.

Moreover, the existence of comets in other stellar systems are recently reported. Since comets in other star systems should be similarly scattered as Solar System comets are, we also should expect the discovery, sooner or later, of an interstellar comet in the Solar System. We have found already the first candidate: C/2007 W1.

Brief description of the research

We plan to undertake two main tasks:

Extension and optimization of our orbit determination software. This means careful positional observation treatment, modern and complete dynamical model of our planetary system, and next taking into account as precisely as possible all external perturbing forces, namely Galactic and stellar perturbations.
Investigation the dynamical evolution of the large number of the observed LPCs discovered so far, using precise tools developed by us. This applies to both, the currently observed comets (say a dozen new near-parabolic comets each year) and also historic comets, with observations dated 100 years ago or more. These old observations can now be re-reduced using modern star catalogues and next used to obtain more accurate osculating orbits, suitable for dynamical evolution investigations.

The extension of the dynamic model of the cometary motion, we plan to carry out in two potentially important for the dynamics of LPCs aspects, namely we want to examine: the impact of various forms of NG acceleration on orbit detarmination for a comets with small perihelion distance and sufficiently long data intervals, including individual treatment of observational data and a direct numerical integration of cometary motion in gravitational field of the Galaxy and nearby stars. In the last point we would like to apply a new, strict methods of numerical calculations in the place where only tidal approximations have been used so far. What seems to be very important, our model will be ready for incorporating the expected large new stellar data from Gaia mission. It is widely expected that this mission will revolutionary increase our knowledge about stellar neighbourhood of the Sun.

Such a homogeneous collection of long-period comet orbits, augmented with their dynamical evolution one orbital period to the past and future will allow us to describe the apparent source of these comets.