Sistematic byass in Celestial Mechanics.

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Abstract

An eigenexperiment shows systematic byass in celestial mechanics calculations when velocity is greater than escape velocity. Evidences and consequences are presented.

Introduction

The calculation of the trajectory of celestial bodies by direct application of Newton's laws involves the calculation of gravitational action (force by time product) and is accurate, but it is very demanding in time and computer resources right now, and it was much more in past time, when there was not availability of computers. Therefore, the calculations of celestial mechanics based on Kepler's laws and the assumption of the constancy of the total energy of the system, or the constancy of momentum, are more often used, due are more simplified because they attend to an initial and a final situation avoiding the calculation of Newtonian gravitational action in many intermediate steps. Today there are no restrictions on these constancy assumptions and on the validity and accuracy of such calculations. But there is evidence that there are systematic errors with this form for calculation in cases where the orbit is not elliptical and to show it is the aim of this report. We are going to do it by analyzing a particular illustrative case. And then we will look at the practical evidence that points to it. Finally, we attend to the consequences and deducible reflections of this evidence.

Comparison in a illustrative case

Let's consider a particular case in which an object in an elliptical orbit and another object in a "hyperbolic" orbit travel the same common trajectory.

Suppose a body in the Oort cloud, at about 20000 AU for example, that suffers a collision with another body that leaves it "stopped" with a practically zero velocity both in tangential velocity to the orbit and in radial velocity. It begins at that moment a new trajectory accelerating by the attraction of the Sun that results in rectilinear and vertical free fall. That is an elliptical orbit of eccentricity equal to 1 (which does not exceed 20000 AU at its apogee) and we can calculate that at a distance of, for example, about 10000 AU its speed will be one or two hundred meters per second and will be directed exactly towards the Sun.

Take to compare an interstellar object entering the solar system exactly oriented towards the Sun with a small initial velocity, for example 1 kilometer per second. In its vertical fall towards the Sun it will suffer a small increase in speed by gravitational action while reaching the distance 10000 AU that we have chosen for comparison. As the comparison is going to be qualitative we do not need to calculate how much that increase in speed will be and is enought to say that it is a speed greater than 1 kilometer per second exactly in the direction of the Sun, as in the previous case. Just note that in this case the trajectory is "hyperbolic", destined to escape the solar system if we imagine that it could cross the Sun or only avoid a direct impact with it by some final planetary disturbance in the inner solar system.

Let us compare the variations in velocity, kinetic energy, potential energy, and total energy of both cases over any distance traveled by a trajectory that is common. We chose a path of only 1 AU at a distance of 10000 AU which allows us to consider practically constant the gravitational acceleration in that section. The initial potential energy is greater than the final potential energy and both are exactly the same for both bodies. In the first case we know from extensive previous experience with the orbits of the inner solar system that the kinetic energy gained is equal to the potential energy lost, so that its total energy remains constant. But this is not because of any magical-mathematical quality of nature, it is a consequence of the increase in speed by gravitational action, which we can quantify as the product of the gravitational acceleration caused by the Sun (the same for both bodies that we can consider punctual) by the time to which it is subjected (the time it takes to travel that distance). Gravitational action (force multiplied by time) is the cause and the variation in velocity (acceleration for that same time) is the result but both behave exactly the same. And it is that same mechanism that accelerates the interstellar body. But in the latter case, although the acceleration of gravity is the same in the same route, the transit time is more than five times less, since its speed (more than 1 kilometer per second) is more than five times higher than that of the first case (less than 200 meters per second), so the increase in speed is less than a fifth. This implies that the increase in kinetic energy, which depends on the square of the increase in speed, is more than 25 times less and therefore more than 25 times less than the variation of its potential energy, since in the same distance it is equal in both cases. As for the total energy (which in the first case we have seen is constant) which is the sum of the kinetic energy plus the potential energy is still greater than in the first case (and according to the usual convention it is positive when in the first case it was negative) but we see that it decreases in its total value by greater loss of potential energy than gain of kinetic energy. In short, total energy is not conserved. Any formulation and calculation that starts from assuming the constancy of the total energy, as current celestial mechanics does in principle even for non-Keplerian orbits (which do not fulfill their first law, being elliptical) is incorrect.

Celestial mechanics introduces systematic errors into calculations of non-Keplerian orbits.

Evidence

And yet that we have observational data from these types of orbits we find evidence of these systematic errors.

With the observation of the trajectory of 1I'Oumuamua (1I from now on) a significant unexplained anomalous "non-gravitational" acceleration was reported. Note that the discrepancy is with calculations that assume a decrease in velocity that exactly compensates for the potential energy gain, with a constant total energy (Celestial Mechanics type). Given the particular case analyzed above and taking into account that the velocity of 1I which is much higher than the escape velocity of the solar system we must assume that the calculation is incorrect. In this case it is directed outward and away from the Sun and its speed decreases due to the gravitational action due to it. The gravitational acceleration is the same as for a body in an elliptical path located at the same point but the time it takes to move away from any distance is much less, and the gravitational action (and the resulting speed variation) is therefore much smaller than estimated. In plain language, there is no extra acceleration, but the braking (acceleration suffered by the time considered) that it undergoes is less than we expect, which results in a higher remaining speed than calculated, as the observations show.

In the case of the discovery and follow-up of interstellar comet 2I Borisov, no anomaly has been reported in the literature. In fact, its similarity to the comets of the solar system has been repeated like a mantra. But, despite being silenced for unknown reasons, there is serious evidence that points directly to systematic miscalculations. And we have "lost" this comet. It is easy to deduce from checks in the JPL database that the last observed position of 2I Borisov is just over 3 AU. Almost the same one that we stopped observing 1I being much less luminous. And almost at the same distance at which it was discovered, in difficult conditions due to its apparent proximity to the Sun, with an amateur telescope, much improved by the discoverer Borisov himself (which speaks very well of his skills and merit), but amateur telescope after all. With all the capabilities of professional telescopes this circumstance is inexplicable. Unless they don't know where to look. Unless the systematic errors of the calculation of its trajectory are so great that all possible attempts have been unable to point in the right direction. All this brings us to an interesting consideration. The calculations have been made from the erroneous assumption of the conservation of total energy, which in geometry assumes that the trajectory is a conic curve, in this case hyperbolic. But in the case of a total continuous (not constant) energy increase as in this case results in a spiral curve. This may explain the lack of effectiveness in the observation and offers the hope of finding later archival images with an adequate calculation of the trajectories, with exclusively Newtonian numerical simulations and without Keplerian assumptions in. The important conclusion that we can reach is that the trajectories of interstellar bodies in their transit in the Solar System is not hyperbolic, it is a symmetric double spiral (a spiral very open in its approach with another symmetrical during its distance).

We found other, older, repeated evidence in the little-studied but well-proven effect called the "flyby anomaly." It has occurred in the case of satellites that have used a near-earth passage to accelerate and overcome the escape velocity so that they can leave the Earth's gravitational field. And it is formally defined as an increase in the total energy of the satellite of unknown cause referring to a difference in the total energy theoretically estimated and the finally observed (always greater). It is clearly associated with this particular maneuver because no such discrepancy has been found in any of the numerous satellites that remain within the Earth's gravitational system (in Keplerian elliptical orbits). And it is even more revealing in the case of a satellite that repeats this maneuver twice as a way to further increase its speed. In this case there is no increase in anomalous energy in the first flyby (it does not yet reach the escape velocity) but yes in the second (which exceeds the escape velocity). This clearly indicates that the effect occurs in the exit path, but only if the velocity is greater than the escape velocity of Earth's gravity at that distance. And no injection of energy of unknown origin is given. Instead it shows that there is a systematic error in the calculations similar to the case with 1I, which underestimates the final total energy.

Non-Keplerian orbits

It should be noted that all these errors shown do not indicate any problem with Kepler's laws. What they do is highlight and value the original formulation of his first law. Where he stated that all orbits are elliptical, with all logic with the observations and data at his disposal, we must read that his laws are applicable to elliptical orbits, only to elliptical orbits. They apply very well, as experience shows, in the relation of the Sun to each of its planets, in the relation of a planet to each of its satellites, or in the relation of the Sun and a planet to one of its satellites. In short, an orbit is Keplerian only if it is elliptical in the gravitational field considered. And its determination is not as complicated as defining the entire shape of the orbit. It is much simpler to compare the velocity of a body with the escape velocity of the gravitational field at that point. If the velocity is less than the escape velocity the orbit is always Keplerian, if it is greater the orbit is always non-Keplerian. And as we have seen, in the latter, the current celestial mechanics introduce systematic errors.

Applicability of celestial mechanics in the calculation of perturbations

Due to the fact that the clear evidence found is not very numerous and we find it in atypical situations we can think at first sight that although the revision and improvement of celestial mechanics is convenient and, perhaps even necessary, it is not urgent because in most situations the calculations are accurate because we work with bodies that are clearly immersed in the gravitational field of the Sun. But the latest reflections on the relationship between speed and systematic errors detected draw a different and very worrying picture that make the improvement of celestial mechanics essential and very urgent that must mobilize astrophysicists and mathematicians in an undoubtedly Herculean effort. Because if the Moon has a very roughly elliptical orbit with respect to both the Sun and the Earth, with the small variations by perturbations of one or the other, and so we can rely on calculating them exactly on the basis of Kepler's laws, that is not true for any other perturbation by any other body. For example Jupiter. If at all times the speed of the Moon with respect to the Sun is less than the escape velocity of its gravitational field (at 1 AU in this case) and also the velocity with respect to the Earth is less than the escape velocity of its gravitational field, the velocity relative to Jupiter, in addition to being extraordinarily variable, it is always greater than the escape velocity of its gravitational field, even at its minimum distance of about 4 AU. In fact the trajectory of the Moon as seen from Jupiter has nothing to do with an elliptical orbit and it is impossible to recognize in its influence the character of Jupiter as some form of central force. And as we can already deduce, its calculated perturbation is overestimated with respect to the actual and effective perturbation. This being the common situation for all bodies. In current practice, the calculation of perturbations introduces errors and moves us away from the objective, which is the calculation of an orbit as close as possible to the real one. And it is more serious the more bodies are included in the calculations because all those results are overestimated, being, as it is now, actual actitude and tendency. On this issue less is more and now we are going in the wrong direction. The positive side is that we see that all perturbations occur in conditions of non-Keplerian orbit and, therefore, are smaller, much smaller, than we consider usual until now. We can without much error renounce its calculation except in the cases of very considerable masses and very close transits, with which, with an easy previous analysis, we can greatly reduce the load demanded of purely Newtonian numerical simulators (they do not share these systematic errors by their continuous and iterative calculation of gravitational action), thus facilitating their use even with modest means. It seems incredible that such a serious situation has not become apparent. Until we keep in mind that the discrepancies between calculations and observation are abundant, generalised and ubiquitous affecting more and more objects when more precise the observations, which has led to the proposal of hypothetical non-gravitational accelerations all very difficult to explain, despite the numerous mechanisms proposed (which all suffer from a clear lack of evidence). I suspect that they are only the reflection of the errors of the calculation, which would explain their lack of homogeneity between different objects and their habitual variability between one orbit and another. It does not seem to be a very clear evidence, but I think it is reinforced by the fact that they occur in both active and inactive bodies, without clear dependence on their size, which makes alternative explanations very difficult and demands their multiplicity, while systematic errors we must expect their presence in all objects regardless of their size or behavior because have a very variable and stochastic character.

As a final reflection to say that the use of the barycenter of the system in the calculations, so much modern and fashionable, does not solve the problems, and it does systematize and camouflage them, so it must be avoided. The barycenter deserves the consideration of a modern epicycle, the result of mathematical conveniences and without any physical basis, and we must to act accordingly avoiding it.