METÓDY RIEŠENIA FYZIKÁLNYCH ÚLOH 3 leto18 – Príklady 1

Cvičenie 21.2.2018

Príklad 1

PROBLEM: If the solar system were immersed in a uniformly dense spherical cloud of weakly-interacting massive particles (WIMPs) then objects in the solar system would experience gravitational forces from both the Sun and the cloud of WIMPs such that

$$F_r = -\frac{k}{r^2} - br$$

Assume that the extra force due to the WIMPs is very small (that is $b \ll k/r^3$). Work to first order in b.

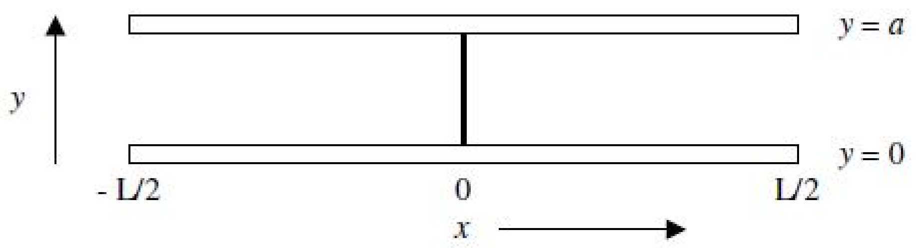
(a) Find the frequency of radial oscillations for a nearly circular orbit. 5

(b) Find the average angular velocity. 3

(c) Find the rate of precession of the perihelion to lowest order in b using the results of (a) and (b). 2

Príklad 2

PROBLEM: As shown in the figure, two parallel conducting plates of dimension $L \times L$ are separated by a distance $a \ll L \to \infty$ and are at electrical potential $V = 0$. A thin charged membrane of height a and length L is inserted perpendicular to the plates at $x = 0$. The potential on this membrane is $V(0, y) = V_0 \sin(\pi y/a)$. The plates and the membrane extend a distance L in the direction perpendicular to the plane of the figure.



(a) Find the electrical potential, $V(x, y)$, in the region between the plates to the right of the membrane (i.e., for $x > 0$). (You may ignore values of $x \geq L/2$.)

(b) Find the sign and magnitude of the charge density, $\sigma(x)$, on the conducting plates at $y = 0$ and $y = a$ to the right of the membrane, $x > 0$.

(c) Find the magnitudes and directions of the forces on the entire upper and lower plates.

Príklad 3

PROBLEM: In studying the hydrogen atom one takes the proton to be a point charge with mass M. Suppose instead that the proton charge is distributed uniformly within the volume of a sphere with radius $r_0 = 10^{-15}$ m.

(a) Using perturbation theory, calculate the shift in energy of the $1s$ level of hydrogen to first order in the perturbation.

(b) Give an order of magnitude estimate of the ratio of the $2p$ and $1s$ level shifts.

Príklad 4

PROBLEM: Molecules of an ideal gas have internal energy levels that are equidistant, $E_n = n\varepsilon$, where $n = 0, 1, \ldots$ and ε is the level spacing. The degeneracy of nth level is $n + 1$. Find the contribution of these internal states to the energy of the gas of N molecules at temperature T.