Mechanik (Theoretische Physik 1)

Sommersemester 2018

Abgabe bis Freitag, 04.05.18, 12:00 neben PH 3218.

Übungsblatt Nr. 4 Dieses Blatt wird in den Übungen vom 07.05. - 11.05.18 besprochen.

Aufgabe 1:
Starring: the Milky Way **2 Punkte**

The Milky Way galaxy has a diameter of approximately 140000 light-years. Its average star has an orbital velocity around the center of the galaxy of 220 km/s, and a typical mass of 1/4 solar masses, with $M_{\text{sun}} \sim 2 \times 10^{30}$ kg.

1. Applying the virial theorem to the collection of stars in the Milky way, estimate the total mass of the latter.

2. Our galaxy is estimated to contain 2.5×10^{11} stars. Can stars explain the total mass of the galaxy?

Aufgabe 2:
Center of mass **3.5 Punkte**

Consider a dumbbell made from two masses m_1 and m_2 linked through a massless rigid rod. The dumbbell finds itself in the Earth's gravitational field. The center-of-mass of the system lies initially at the origin of the reference frame, from which the dumbell is thrown in some chosen direction.

1. Obtain the equation for the trajectory of the center of mass, by starting from the equations of motion of the masses m_1 and m_2.

2. What is the trajectory of the center of mass, given an initial velocity $\mathbf{v}_0$?

3. The total angular momentum is given by the sum of a center-of-mass contribution $\mathbf{L}_{CM}$ and a relative contribution $\mathbf{L}_r$. Calculate $\mathbf{L}_{CM}$.

4. Write the equation of motion for the relative position $\mathbf{r} = \mathbf{r}_1 - \mathbf{r}_2$. What can be said about the relative angular momentunm $\mathbf{L}_r$?

5. Show that the masses m_1 and m_2 move in circles around the center of mass, with constant angular velocity. What is the relation between the radii of the circles described by the masses?

Aufgabe 3:
Galilean Invariance of the Lorentz Force **1 Punkt**

Briefly show that if a point-like charge q is subject to the Lorentz Force, the Newton's Law for its motion does not have the same form in all inertial systems. In particular, consider the particle's comoving coordinates and assume that the fields behave like vectors under Galilei transformtions.

Aufgabe 4:
Potential of a Force Field **3.5 Punkte**

Consider a system in which the force exerted by a charge q_μ on a charge q_ν is given by:

$$\mathbf{F}_{\mu\nu} = q_\mu q_\nu \cdot \frac{(\mathbf{r}_\nu - \mathbf{r}_\mu)}{|\mathbf{r}_\nu - \mathbf{r}_\mu|^3}$$

1. Prove that the force field is irrotational.
2. Find a potential $U_{\mu\nu}$ for the force field such that $\mathbf{F}_{\mu\nu} = -\nabla U_{\mu\nu}$.