Homework 3

Due date: Feb 25, 2019 (Mon, at class time). No late homework.

1. (15 pts) A helium nucleus (fully ionized ^{4}He, mass $4m_u$, where $m_u = 1.66 \times 10^{-24}$g is the atomic mass constant) and a carbon nucleus (fully ionized ^{12}C, mass $12m_u$) interact with each other through the Coulomb force between them, and there is no any external force. Explain whether we expect electric dipole radiation from this system.

2. (45 pts) A spaceship left a cloud of plasma in space. The spherical cloud, with radius R and uniform number density n_e of free electrons, is located at a distance d from the Sun ($d \gg R$ and $d \gg R_\odot$, where $R_\odot$ is the radius of the Sun). The angle between the cloud-Sun direction and the cloud-Earth direction is θ. The cloud is optically thin (i.e., multiple scatterings can be neglected) and shines because of Thomson scattering of the sunlight by the electrons. The luminosity of the Sun per unit frequency is L_ν.

(a) What is the cloud's emissivity j_ν (power per unit frequency per unit volume per solid angle) towards the Earth direction?

(b) What is the intensity I_ν that an observer on the Earth would observe along the direction to the center of the cloud?

(c) The intensity of the scattered wave can be decomposed into contributions from components in and perpendicular to the Sun-cloud-Earth plane, respectively. What are the intensities from these two components? What is the degree of polarization of the scattered light?