Physics 7C – Section 2
Fall Semester 2003
Second Midterm Exam (R. Marrus)
11/04/03

1) A single slit 1 mm wide is uniformly illuminated by light of wavelength $\lambda = 589$ nm. A diffraction pattern is observed on a screen 3 m behind the slit. Throughout this calculation you may assume that the angles subtended at the slit are small.

a) Find the distance between the first diffraction minima on each side of the central maximum.

b) The width of the slit is now doubled. Find: (I) The distance between the first diffraction minima on each side of the central maximum. (II) The factor by which the intensity of the central maximum changes.

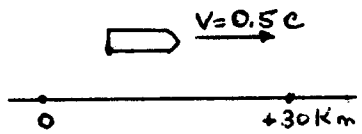
c) The slit is now illuminated with a second source of light of wavelength λ'. The value of λ' is such that its second diffraction minimum on one side of the central maximum coincides with the third diffraction minimum produced by light of wavelength λ. Calculate λ'.

2) In an inertial frame fixed relative to the earth, a red light suddenly flashes at the origin and a white light suddenly flashes at a point + 30 km from the origin. In the earth's frame both flashes are simultaneous. A spaceship moves with a speed $v = 0.5c$ parallel to the line between the 2 points at which the flashes occur. To an observer in the spaceship:

a) What is the separation of the two lights?

b) What is the time interval between flashes?

c) Which flash occurs first?



3) An x-ray photon of wavelength 0.0021 nm is Compton scattered by a free electron (initially at rest) through an angle of 30^o from the incident direction. Find the kinetic energy in (eV) of the recoiling electron.

4) Determine the radius of the star Procyon B from the following data: the flux of starlight reaching us is 1.7×10^{-12} watt/m^2, the distance of the star is 11 light years, and its' surface temperature is 6600°K. Assume the star radiates like a blackbody.

5a) Light of frequency 10^{16} Hz is incident on a gas of hydrogen atoms in the ground state. What is the kinetic energy (in eV) of the emitted electrons?

5b) A hydrogen atom makes a transition from n=3 to n=2 and emits a photon. Calculate the energy of the recoiling nucleus. You may assume the recoil energy is small compared to the photon energy.

$h = 6.62 \times 10^{-34}$ joule-s $= 4.14 \times 10^{-15}$ eV-s
$c = 3 \times 10^8$ m/sec.
m_e(electron mass) $= 9.1 \times 10^{-31}$ kg. $= 511$ keV/c^2
Mp (proton mass) $= 1.67 \times 10^{-27}$ kg $= 938$ MeV/c^2
1eV $= 1.6 \times 10^{-19}$ joule
e(electron charge) $= 1.6 \times 10^{-19}$ coulomb
R(Rydberg constant) = 13.6eV
$k = 1/(4\pi\varepsilon_o) = 9 \times 10^9$ MKS
σ (Stefan-Boltzmann constant) $= 5.67 \times 10^{-8}$ W/m^2-s