Saturday, March 4th, 2006

Phys 340: HOMEWORK ASSIGNMENT No. (3): CLASSICAL FIELDS
Due Date: WEDNESDAY, MARCH 15th, 2006

. To be handed on Wednesday, March 15th. Late assignments will not receive a mark

(1) EM Fields: This question deals both with your intuition and conceptual feel for classical EM field configurations, and with your philosophical understanding of them, and their historical roots. No mathematical understanding is required.

1(a) The basis of the EM field

(i) Describe in what way we should think about the EM field- what kind of existence does it have, how can we *define* it, and what evidence do we have for its existence. Distinguish carefully between the EM field itself, and what are usually called 'electric' and 'magnetic' fields. What is the relationship between electric and magnetic fields, on the one hand, and the EM field, on the other? And how do we know that electric and magnetic fields are out there?

(ii) The waves that can be produced by exciting an EM field in an oscillatory way are called EM waves. Describe these, giving a picture of the how the magnetic and electric components vary in space and time. Then give 3 examples of EM waves, explaining what distinguishes them from other EM waves.

1(b) Static Electric and Magnetic Fields

(i) Show the electric field lines near a pair of electric charges, having charges q and $-q$ (an electric dipole). Assume the only fields around are those generated by these 2 charges.

(ii) Show the equipotential lines (contours of constant electric potential energy) for the same pair of charges as in (i).

(iii) Show the magnetic field lines near a single loop of wire carrying a current- assume there are no other magnetic fields around apart from that generated by the loop.

(2) WAVE INTERFERENCE: All fields support wave-lime disturbances. Here are some important aspects of these, true no matter what field we are talking about, brought out in short questions.

2(a) Consider a screen or backstop which receives waves passing through 2 different parallel slits, having been emitted somewhere on the other side of the slits from the screen. Show first what the intensity of the wave will look like when both slits are open- we assume here that the slits are both very narrow, with width not much greater than the wavelength of the waves travelling through them. Then, second, show what the intensity on the screen will look like if only one of these slits is open. You will certainly find it helpful to draw your results.

2(b) Now, a very important question. Explain why it is that the results of this experiment are impossible to understand if light is considered to be simply a set of particles propagating through space according to Newtons's laws.

(3) **GRAVITATIONAL FIELDS, CURVED SPACETIME, and COSMOLOGY**

3(a) Suppose you lived in an entirely 2-dimensional world- not only are you not aware of any higher dimensions, but there is no way even in principle for you to know about them directly. Can you nevertheless explain 2 ways you might test to see whether the geometry of your 2-d world is flat (ie., Euclidean)?

3(b) The spacetime field is a rather peculiar one for our common sense understanding, because

it does not exist 'in anything'. Space and time, formerly a 'receptacle' for everything else, now becomes an object in itself - a field - but this field is not (at least in Einstein's theory) embedded in any other 'space'. Nevertheless we can know about it, in the same way as with the EM field, through distortions of it. Explain how both gravitational fields and gravity waves are distortions of spacetime, and explain how we can at least in principle do an experiment to see each of these distortions (note that gravity waves have not yet been observed).

3(c) General Relativity predicted a remarkable variety of effects which were subsequently discovered, including (i) the bending of light by the sun (ii) gravitational lensing (iii) gravitational collapse and black holes (iv) the expansion of the universe, now understood as a closed spacetime (there are many other predictions as well). Pick any three of these, and give a very brief description of the effect and its history.