Solution Exercise 4 plasma physics 2009

me = electron mass [kg]
mp = proton mass [kg]
ee = electron charge [C]
μ0 = magnetic permittivity
r=distance to current wire [m]
i=current [A]
b=magnetic field [T]
ω=cyclotron frequency [rad/sec]
f=ω/(2π) = frequency [Hz]

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me = 9.1094 × 10^-31;
mp = 1.6726 × 10^-27;
ee = 1.6022 × 10^-19;
μ0 = 4 π 10^-7;
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5 a

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r = 1.0;
i = 100.0;
b = μ0 i / (2 π r);
ωce = ee b / me;
ωcp = ee b / mp;
Print["ωce = ", ωce, " rad/s"]
Print["ωcp = ", ωcp, " rad/s"]
Print["fce = ", ωce / (2 π), " Hz"]
Print["fcp = ", ωcp / (2 π), " Hz"]
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ωce = 3.51769 × 10^6 rad/s

ωcp = 1915.82 rad/s

fce = 559 857. Hz

fcp = 304.912 Hz
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5 b − electron motion perpendicular to B

The magnetic field lines are circles around the current−carrying wire.
1. Electrons gyrate around these lines in the plane of the wire.
The direction is "diamagnetic", i.e. in the same direction as the current
when passing through the circular fieldline, thus reducing the magnetic field.
2. Gradient(B) is directed towards the wire. Hence there is a Grad(B)−drift
parallel to the wire. The gyroradius is smallest when the electron is
closest to the wire, so that using observation (1), you see that the drift
is directed in the opposite direction as the current.

5 c − electron motion parallel to B

1. The electrons do not gyrate.
2. The curvature of the field lines is directed towards the wire.
Therefore, there is a curvature drift. As usual, it is in the same direction as
the Grad(B)−drift, see 5b.
3. The electrons stay at the same distance of the wire and therefore at
constant field strength. Therefore, there is no mirror effect.

5 d − electrically charged wire

There is an electric field pointing towards the wire or away from it, depending
on the sign of ϕ. In case 5c the particle gyrates and hence there is an additional
E x B drift parallel to the wire.
In case 5b the particle does not gyrate, so the effect of the electric field is to
accelerate the electron towards or away from the wire. This motion is perpendicular
to the magnetic field and immediately becomes gyration, so that we have
E x B drift, Grad(B)−drift, and curvature drift.