Electrodynamics Exam
29 January, 9.00-12.00 uur

Rules:

- Closed book part ≤ 2 hours, open book part all remaining time.
- Please formulate clearly and concisely. Read carefully.
- Grade $= 1 + \frac{score}{10}$.

1. **Radiation and Special Relativity [8+8+8+8+8=40 points]**

   (a) Describe in words and pictorially how radiation is produced.

   (b) Give the basic ideas underlying special relativity, and illustrate this quantitatively for time with the well known frames K and K'.

   (c) Can a relativistically moving observer and one in rest agree on the total absorbance, as well as scattering properties, of an observed medium? State why (not).

   (d) Construct Lorentz invariants using all the properties of the source function S_ν and photon frequency ν (always give units).

   (e) Explain conceptually how beaming of radiation works by considering an instantaneous restframe for a charge and an observer in relative motion.

2. **Radiation Basics [5+5+5+5=20 points]**

   (a) State what the working mechanisms of Bremsstrahlung, synchroton emission and inverse Compton scattering are.

   (b) Explain what drives the common $1 : \gamma : \gamma^2$ progression in photon energy of these three radiation processes.

   (c) Derive, for a purely scattering medium of large optical depth τ_ν, the relation between the Compton y parameter, the fractional change in photon energy per scattering and the optical depth.

   (d) Explain the distinction between thermal and blackbody radiation, and relate this to Kirchhoff's law.

> $\qquad$ end of closed book part, please hand in questions 1 and 2.

3. An Observed Spectrum [10+10+10=30 points]

Consider the drawing below.

$\log I_\nu$

$\nu^{5/2}$ ν^{-1}

$\uparrow$
100 MHz

$\log \nu$
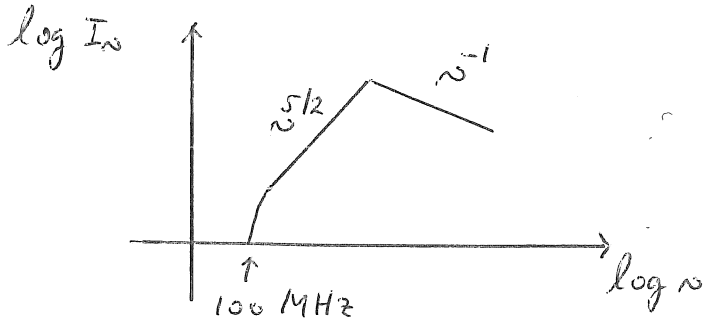
(a) What can cause the different power-laws in the spectrum? Use formulas to explain.

(b) What physical causes can you think of to explain the low frequency cut-off at 100 MHz in the spectrum?

(c) Estimate a typical gamma factor for this source and discuss it, for synchrotron emission and inverse Compton scattering, in terms of a power-law distribution for the electron energy.