Detection of Light: Exercise 8

Set: Fri 8th Apr 2016,
Due: Fri 15th Apr 2016

1 Heterodyne Performance [10 marks]

We would like to design a heterodyne receiver for observations at $\lambda = 200\,\mu$m. This incorporates a cylindrical diode photomixer made from HgCdTe ($\kappa = 10$) of diameter 85 μm and depletion region of width 1.5 μm, which may be modelled as a simple RC circuit. The input impedance of the amplifier is 130 Ω.

a Calculate the IF bandwidth of the receiver, assuming this is limited by the frequency response of the mixer.

[3 marks]

b Calibration observations are made of two blackbodies with temperatures $T_1 = 3000$ K and $T_2 = 200$ K, for which the receiver measures 3.7 V and 1.2 V respectively.
i) Calculate the effective noise temperature T_N of this receiver.
ii) In which noise regime is the receiver operating?
iii) Hence calculate the RMS amplifier noise current of our heterodyne receiver.

[3 marks]

c We now wish to compare the performance of our receiver with that of the bolometer we designed in Ex.7 ($\eta = 0.55$), operated through a spectral band of width 20% of the central frequency.

i) Calculate the fractional S/N achieved by our heterodyne receiver with respect to the bolometer: which one performs better under the given conditions?
ii) At which limiting bandwidth would the two detectors provide equal performance?
iii) What is the fundamental assumption under which this trade-off is valid?

[4 marks]