Exercise sheet 12

As for the previous weeks, upload your own solutions to the exercises into ILIAS. You can work out the problems in groups, just make sure to upload your individual solutions. The upload format should be a PDF report including the R code you wrote, snapshots of the corresponding plots and a narrative about your results and conclusions.

Exercise 1 – Virus and strains

Consider the following situation: an emerging virus is introduced in a fully susceptible population of 100,000 individuals. There are two strains of the virus: a first, generic strain (strain 1) that has an infectious contact rate (β_1) of 0.2 per day, and a variant strain (strain 2) that has an infectious contact rate (β_2) that is 50% higher. For both strains, the recovery rate (γ) is 1/7 per day, and infection to any of the two strains provides full immunity to both. We ignore co-infection, so that one individual cannot be infected by the two strains at the same time. We assume that 500 individuals are infected with strain 1 and 5 individuals are infected with strain 2 at the start of the simulation (t_0).

1. Create a compartmental model with ODEs (inspired from the SIR model) following the previous assumptions (two strains, no co-infection and infection to any strain is followed by immunity to both strains).
2. Simulate this situation in R with package deSolve for 200 days using the provided numerical values for the parameters and the initial conditions.
3. Produce two plots: one showing the number of people in each compartment over time, the other showing the proportion of individuals infected with strain 2 among all infected people in time.

Exercise 2 – Exoplanet radius inflation

Start by loading the dataset `gas-giants.csv` from the following github repository: https://github.com/bodemory/ASMP.

Load then the data in R:

```
> data <- read.csv(file="gas-giants.csv", header=TRUE, sep=",")
> str(data)
```

Description
This dataset contains planets with masses between $0.5 - 3.5 M_J$ (Jupiter masses), with radii in R_J (Jupiter radii) and $\log_{10}(\frac{\mathrm{F}}{\mathrm{Wm}^{-2}})$, where F is the incident flux coming from the host star onto the planet. Planets of this type exhibit the so-called hot-Jupiter inflation: above a certain incident flux, their radii become dependent on the incident flux, and get significantly larger than what would be expected from simple models for gaseous planets.
The uncertainties (or error bars) for each parameter are given as radius_err, mass_err, etc. You should treat each measured value as being drawn from a normal distribution, with a mean at the "true value" of the parameter, and a standard deviation equal to this uncertainty, i.e.: mass $\sim$ Normal(M, mass_err), where M is the true mass of the planet.

1. Take the subset of giant planets with $mass > 0.5$ and $\log F > 5$. Fit a simple model of your choice for radius vs. $\log F$, i.e. not a multi-level model. Do your findings support the idea that these high incident fluxes have an incidence on the radii?
2. Repeat (1) with a multi-level model.
3. We want to find the flux value at which radius inflation starts to have an effect, so we will use the full dataset (i.e. do not discard planets with $\log F < 5$). Build a multi-level model with this hypothesis: *below a flux threshold, the radii do not depend on flux, but above this threshold the radii increase linearly with* $\log F$. Fit this threshold as a model parameter. What value do you find? Does it match the behaviour in the data?
4. Treat the predictor as a varying slope in (2) and (3).