INSTITUT FÜR THEORETISCHE PHYSIK HEIDELBERG
PROF. DR. LUCA AMENDOLA
COMPUTATIONAL STATISTICS – SUMMER SEMESTER 2022 –

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Please, send (in pdf) or hand in the solution to this exercise sheet to your tutor, following their instructions, and carefully respecting the delivery date shown below. All exercise sheets will be graded. You can solve them individually or in pairs (with another student of the same tutorial group). In the latter case deliver please only one document with the solutions. Write the name of the file in the following format: X.Name1.Surname1 or X.Name1.Surname1-Name2.Surname2.pdf, with X being the number of the corresponding exercise sheet.

Exercise sheet 10

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10.1 Python exercise: MCMC (6pt)

Please download a publicly available MCMC code (for example Emcee `https://emcee.readthedocs.io/en/stable/`). A posterior distribution is defined by a three dimensional Gaussian with parameter covariance matrix

$$\begin{pmatrix} 1. & -0.41 & -0.35 \\ -0.41 & 0.44 & 0.24 \\ -0.35 & 0.24 & 0.81 \end{pmatrix}$$

and zero mean. Use the MCMC code to sample this posterior distribution. Create a plot that shows the one and two dimensional marginalized confidence regions at 68% of the posterior probability distributions of the parameters and compare graphically the numerical MCMC results with the theoretical results.

10.2 Fisher manipulation (5pt)

Given the Fisher matrix

$$F = \begin{pmatrix} 9. & 10. & 8. \\ 10. & 14. & 7. \\ 8. & 7. & 13. \end{pmatrix}$$

1) compute the Fisher matrix obtained adding a prior of standard deviation $\sigma_2 = 0.5$ on parameter 2 (priors centered on the same likelihood mean) (1pt); (*hint*: the prior constrains parameter 2, but leaves the others free, so with very large variance; what is the inverse, i.e. the prior Fisher matrix, for such a covariance matrix, in the limit of infinite variances for parameters 1 and 3?)

2) compute the Fisher matrix after adding to the previous matrix a prior on parameters 1 and 3 with standard deviations $\sigma_1 = 1, \sigma_3 = 0.5$ and correlation coefficient 0.1 (1pt);

3) compute the Fisher matrix after marginalizing over parameter 2 the previous matrix (1pt);

4) compute the Fisher matrix after maximizing over parameter 3 the previous matrix (1pt);

5) what is the initial (before all the manipulations) and final error at 1σ on parameter 1? (1pt);