

Basic probability theory and statistics  
– Conditional probability, and Bayes' theorem. Bayesian inference versus frequentist inference.

Random variables and probability distributions  
– Populations vs. samples. Discrete and continuous probability distributions and their moments. The Central Limit Theorem.  
– The cumulative distribution function. Expectation values, variance, standard deviation, covariance, correlation coefficients, correlated and uncorrelated random variables.  
– Distributions of functions of random variables.

Statistical inference

– Estimators: mean, variance, bias. The bias-variance tradeoff.  
– Statistical models. Likelihood: frequentist and Bayesian interpretations. The Maximum Likelihood Estimator, Fisher Information, and the Cramér-Rao Theorem. The  $\chi^2$  and  $\chi$  distributions.  
– The Student's  $t$  distribution and the  $t$  statistic.  
– The Bootstrap Method.  
– Confidence sets and (one- and two-sided) intervals. Confidence bands.  
– Hypothesis testing. The  $p$  value. Parametric and nonparametric tests. The empirical distribution function. The KS test.

## Visualising data

- Five-number summaries and the box-and-whisker plot. Histograms. Nonparametric density estimation and Kernel Density Estimates.

## Bayesian inference

- Priors and prior selection. Bayesian point/location and interval estimates. The Highest Posterior Density Interval. Prior- and data-dominated posteriors. The Jeffreys Prior.
- Model selection, complexity, and information criteria. The posterior predictive distribution.

## Sampling techniques

- Monte Carlo. Rejection and importance sampling. Markov Chains and Markov Chain Monte Carlo. The Metropolis-Hastings Algorithm. Implementations in astronomy: emcee.

## Regression

- Heteroskedastic uncertainties. Ordinary least-squares. Detection limits. Outliers and robust regression. Bayesian outlier rejection (marginalization). Goodness-of-fit. Bivariate measurement uncertainties and intrinsic scatter.

## Advanced topics: MCMC and Bayesian modeling

- It is likely that we will invite a couple of experts to speak on these subjects. If so,

the dates/times will be announced in advance,  
and the videos will be made available after  
the sessions.