Remember to commit on GitHub

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| What is an open cluster?  Few dozen or more stars, that remain in the same group after forming in the same molecular cloud, which are shredded after formation due to tidal forces. They tend to have lots of young stars.  A lot of open clusters that we see are young  What are the typical compositions of stars in an open cluster?  They should be similar, but not all the same, due to metal enrichment from large stars dying early on in the open cluster formation.  Gas collapses and fragments, after 50 Myrs a 20 solar mass star will have died and enriches the cloud. After 50 Myrs there is a short break before type 1a supernovae kick in.  In most clusters (from spectroscopic analysis) it looks like there is a certain consistency in the elemental abundances for the stars in open clusters.  Which makes people think the star formation has been rapid and bursty and then stopped, because if the stars continued to form in the open cluster, the second set of stars would be enriched by the alpha elements released by the type 2 supernovae from the first wave of star formation. Then after 100-115Myrs the gas would be enriched by iron (which is easy to see) because then the type 1a (white dwarf spiral collision path) produces a lot of iron (as well as a number of other things).  There isn’t a huge spread of iron in open clusters, it suggests the star formation happens over a short time scale.  Potentially star quenching occurs preventing further star formation. |
| Hierarchical modelling – crash course |
| Age estimates for stars in open clusters  For age estimates for stars in OC we need to build a model and then explore it using a HMC specifically the No U-turn Sampler (NUTS)  Most non-bayesian algorithms want to find the highest probability point given x,y  Bayesians like to try and estimate the probability density distributions rather than the point where you’re most likely to get the data given x,y  MCMC – randomly walks in a direction and is very inefficient  Hamiltonian Monte Carlo takes a random walk through space by taking a step in a random direction and if it continues in that direction is determined by how the probability of the new position changes, so decrease in probability is unlikely to be selected on a scale of likelihood depending on how low the new probability is and the opposite is true for good new probabilities from the step.  The steps taken build a histogram, and builds the distribution because the steps eventually perturbate about the highest probability location. |
| HMC - Hamiltonian Markov chain  Combines MCMC and Hamiltonian Monte Carlo  If it steps in a direction that looks good it continues to step in that direction and you can train it to quickly deviate to the centre of the distribution    HMCs can deal with many more parameters than MCMCs. |
| The Type 2 supernovae enriches Mg and Fe however as it’s compared to solar values the increase in magnesium is much greater.  Type 1a don’t really enrich the alpha elements (elements that are enriched by type 2 i.e. magnesium, oxygen, helium but magnesium is the one of those that is easily measurable). However lots of iron is produced.  We could build in the concept that the age of the star in an open cluster is not from some random normal distribution but instead they form from a 2d distribution.  Or even crazier that they can be from 2, 2d distributions.  Posterior age estimates for stars in an open cluster  We could simulate the 2, 2d planes  AIMS = asteroseismic inference on a massive scale – uses MCMC  Use AIMS to get individual ages and build a model which be explored using a HMC specifically the No U-turn Sampler (NUTS)  Age estimates from asteroseismic data, but you can also get rotational estimates from dwarf stars  See M67 |
| For next week:  Do a literature search: what is there on asteroseismic open clusters, with published age estimates  See M67, NG6819, NG6791, rupprecht 47/147?  Reviews on open clusters: best ones summarise the whole field i.e. here is the current status of research on open clusters, we know what open clusters are because this person did this that and the other. Ted Von Hippel (review from 2005)  “Open Cluster Review Article”  Bring laptop Install Pymc3  Reminder: list of objects worth checking  Next week: walk through hierarchical modelling (make some data, do some analysis)  If there was satisfactory existing data that is citable for the proposal that would be great. |
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Hierarchical Bayesian modelling GitHub repo we should be added to, so we can see how it was made