Probing Dark Matter Substructure with Stellar Streams and Neural Simulation-Based Inference

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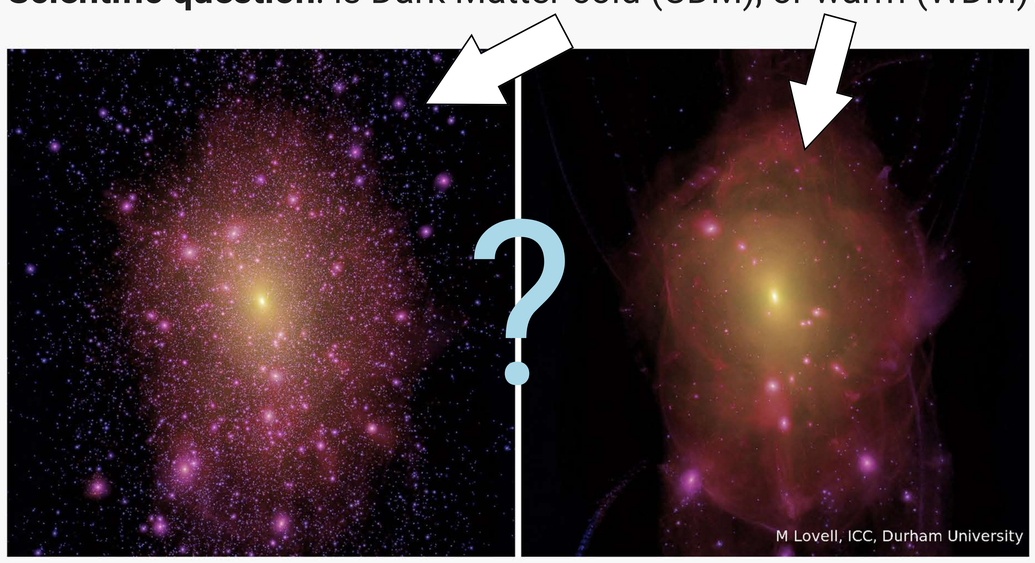
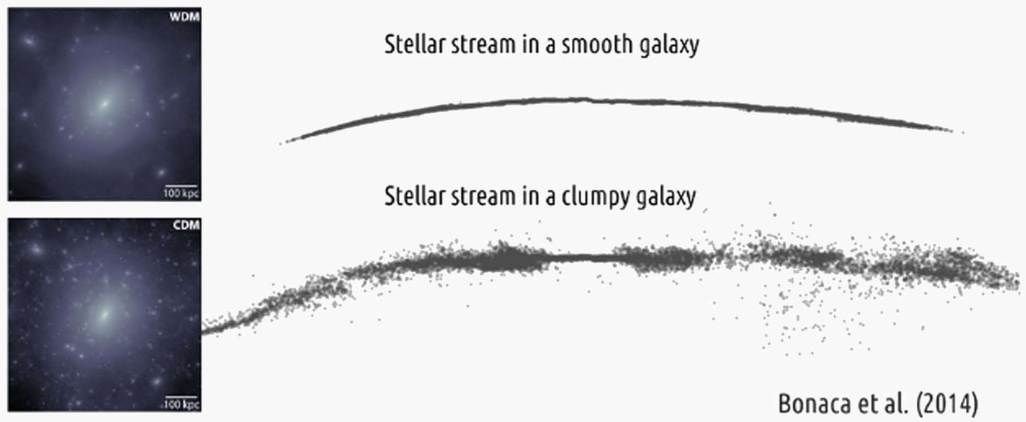
Scientific question: is Dark Matter cold (CDM), or warm (WDM)?



Use **stellar streams** to probe dark matter substructure



Simulate interactions between streams and dark matter subhaloes!

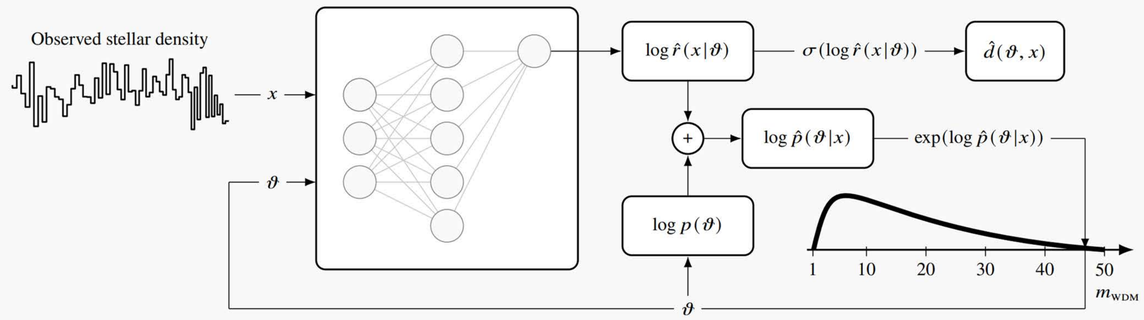
Inferring the posterior p(dark matter mass | stream density) is intractable!

Notice that: $p(\theta|x) = \frac{p(\theta)p(x|\theta)}{p(x)} = p(\theta)\frac{p(x|\theta)}{p(x)} = p(\theta)r(x|\theta)$

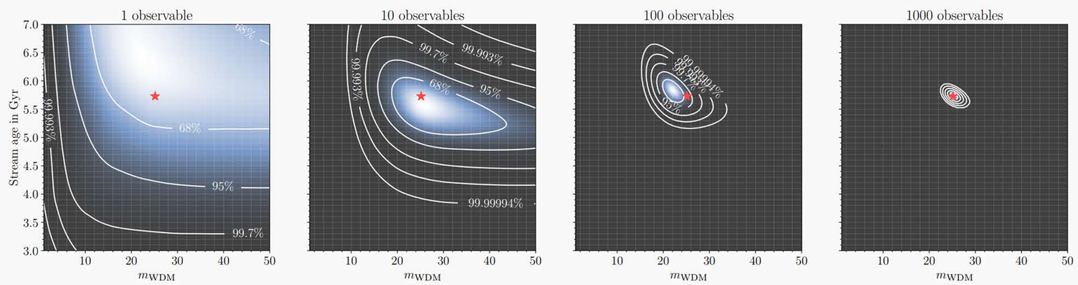
Method: train an arbitrary classifier to discriminate between the joint, and the product of marginals.

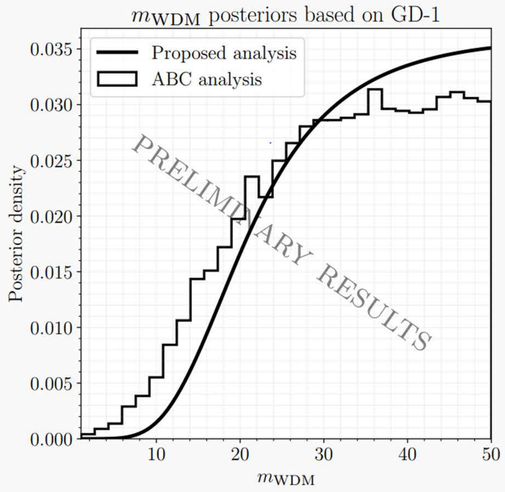
You can show that: $d(x,\theta) = \frac{p(x,\theta)}{p(x,\theta) + p(\theta)p(x)}$,

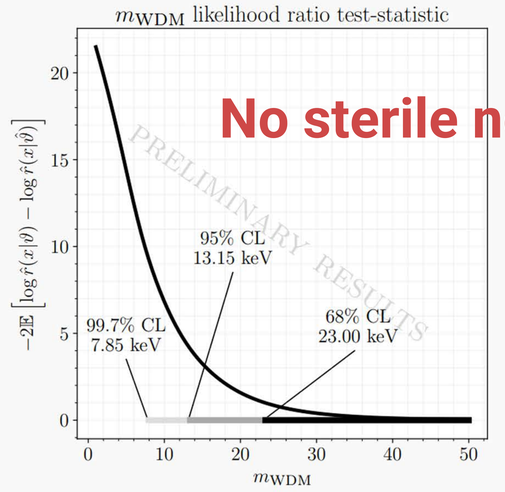
$$\frac{1 - d(x,\theta)}{d(x,\theta)} = \frac{p(x,\theta)}{p(x)p(\theta)} = \frac{p(x|\theta)}{p(x)} = r(x|\theta)$$



Trustworthy approximations? Compute diagnostics!







No sterile neutrino?