Exploring the Dark Side of the Universe

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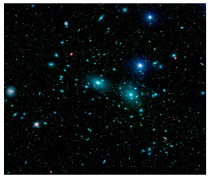
What is Dark Matter?

1933 - Fritz Zwicky discovers Dark Matter while studying the **Coma Cluster.**

Galaxies at edge of galaxy clusters move faster than predicted by Newton's Law of Gravitation.

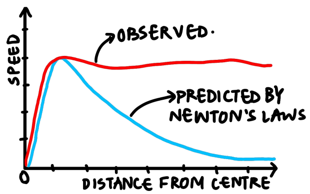


Coma Cluster
Image : NASA/JPL-Caltech/L.Jenkins

Dark Matter is required to explain these observations.

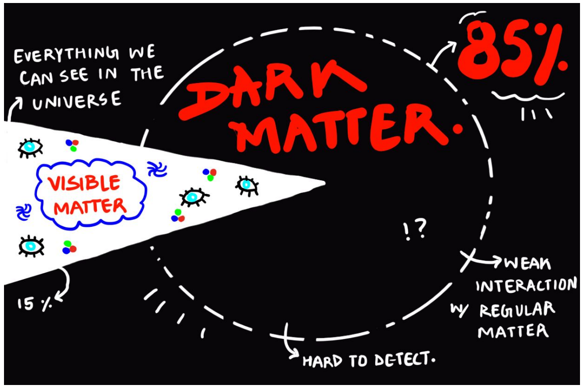
1968 - Vera Rubin studies **Galaxy Rotation Curves.**

Stars far from centre of galaxy have velocity higher than predicted by Newton's Law of Gravitation.



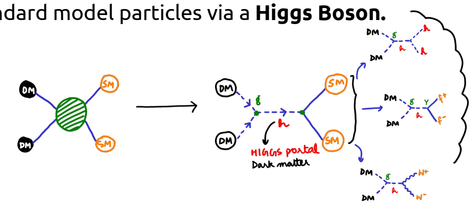
Galaxy Rotation Curves are experimental evidence for the existence of dark matter.

How much Dark Matter exists in our Universe?



Higgs Portal Dark Matter

In this model, dark matter particles interact with standard model particles via a **Higgs Boson.**



Γ = **interaction rate** between dark matter and standard model particles.
g = **coupling constant**. It defines strength for interactions between dark matter and standard model particles.
m = **mass** of dark matter particle.

$$\Gamma \propto \frac{g^2}{m^2}$$

The Boltzmann Equation

The **Boltzmann Equation** is a first order differential equation relating the **abundance** of dark matter.

It tells us how dark matter abundance changes with time.

ABUNDANCE OF DARK MATTER

$$\frac{dY(x)}{dx} = -\frac{\Gamma}{H(x)}\left(Y^2(x) - Y_{eq}^2\right)$$

$x \propto$ TIME

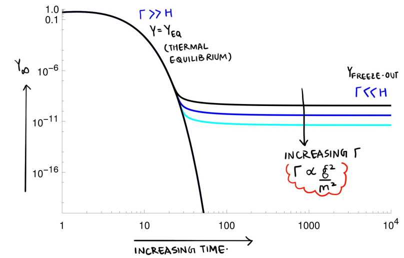
INTERACTION STRENGTH OF DARK MATTER PARTICLES

ABUNDANCE OF PARTICLES IN THERMAL EQUILIBRIUM

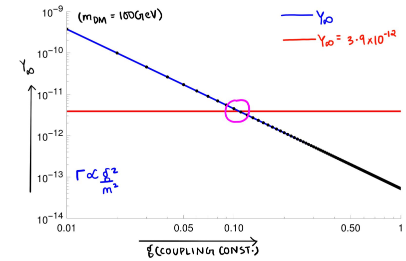
To reproduce the observed dark matter abundance
Y(current time) = (6.96x10^{-10})/m

In Higgs portal dark matter, this **constraints** the value of coupling constant **g** for fixed dark matter mass **m**.

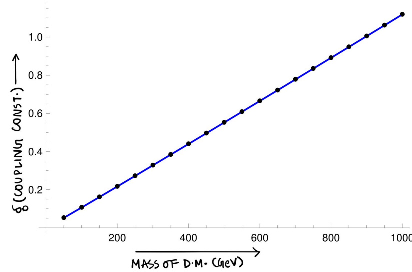
Results!



Dark matter abundance for sample Γ values. Plot also shows freezing out dark matter abundance at late times.



Plot shows g≈0.15 to reproduce the observed dark matter abundance for fixed m=100 GeV



Final result showing g and m values to reproduce the observed dark matter abundance in the universe.

I am currently adapting my code to examine dark matter abundance for a more precise formula for Γ.
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