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Discovery and Background Info

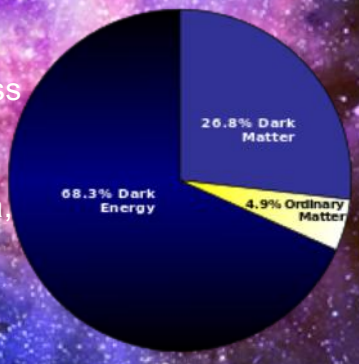
Discovery of Dark energy

- Einstein's biggest 'blunder'? (Hetdex, 2019)
- 1998 officially by the American and Australian international astronomy teams (Nasa, 2019)
- Americans- Saul Perlmutter and Adam Reiss
  Australian- Brian Schmidt (Nasa, 2019)

Discovery and Background Info

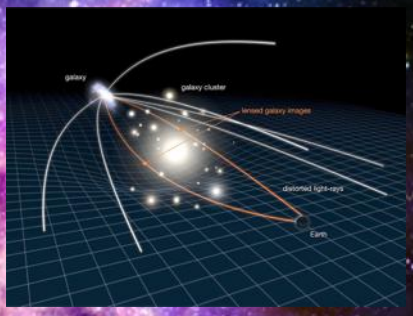
Discovery of Dark Matter

- Stars at the edge of the galaxy should travel much slower but…(National Geographic, n.d)
- Not the case, stars feel the pull of an unseen mass (National Geographic, n.d)
- Dark matter makes up 25% of the universe (Nasa, 2019)
- Yet to be observed directly by scientists (Nasa, 2019)
- Dark energy makes up roughly 68-70% of the universe (Nasa, 2019)



Discovery and Background Info

So what is it...



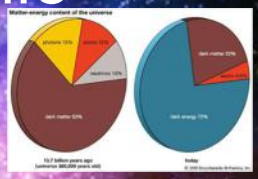
- Dark Matter is matter that emits minimal to no light but can be detected by its gravitational influence (attractive gravity) (Hetdex, 2019)
- Stars in outer regions (discovery) (Annenberg Learner, 2017)
- Velocity dispersions (Nasa, 2019)
- Gravitational lensing (Grocutt, n.d)

Discovery and Background Info

So what is it… Part 2

- More unknown than is known (Riess, 2019)
- Hypothesized to permeate all of space (Strauss, 2015)
- Can determine the amount because… (Riess, 2019)
- Influence on the expansion (Riess, 2019)
- Evenly distributed through spacetime (Riess, 2019)

Discovery and Background Info

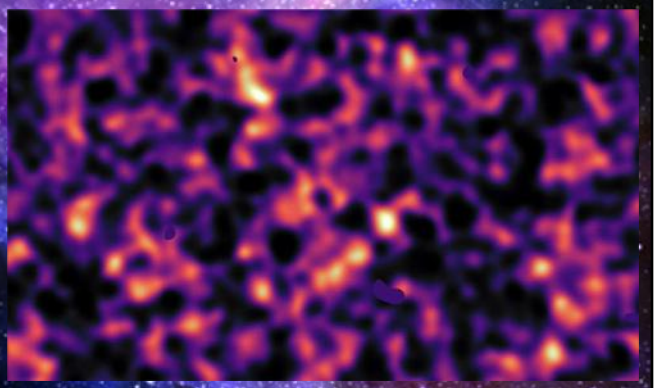


Eventually...maybe?

- Phantom energy (Physics of the Universe, 2013)
  - Big rip
- Dark energy might.... (Physics of the Universe, 2013)
  - Dissipate
  - Eventually become attractive (crunch)
  - Dark energy cycle
- Need to find out what both dark energy and dark matter are first...

Possible Explanations - Dark Matter

WIMPS (Weakly Interacting Massive Particles)

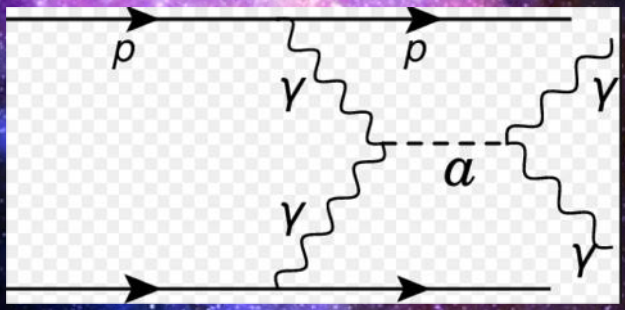


- Catch all term for any particle considered to be Dark Matter (NASA, 2019)
- Independently predicted by many different particle theories from different labs and scientists from around the world at similar times (Burne, 2018)
- Correctly predicts the mass needed to explain extra gravitational forces (WIMP Miracle) needed to accelerate expansion of the universe (Burne, 2018)

Possible Explanations - Dark Matter

Axions

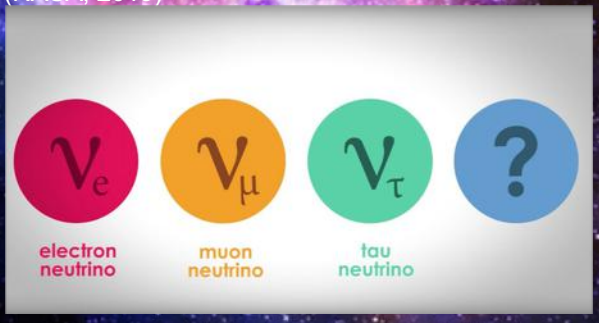
- Theoretical particle to solve an unsolved equation in Quantum Theory (Burne, 2018)
- Predicted to only work weakly with ordinary matter (like WIMPS)(Ashfaque, 2015)
- Are the right size for us to miss them (1.78x10^-42 kg)compared to the size of an electron (9.10x10^-31)(NASA, 2019)
- Decays into two photons and can also be made by the collision of two photons (Burne, 2018)
- Talked about new research into Axions at the University of Washington, partnered with the Fermi Lab(Ashfaque, 2015)(UofW, 2019).



Possible Explanations - Dark Matter

Sterile Neutrinos

- Neutrino is a particle that interacts with matter only via the weak subatomic force and gravity. Is smaller than an electron and has small or negligible mass (Burne, 2018)(NASA, 2019)
- Regular neutrinos heavier cousin in terms of mass (NASA, 2019)
- Minimally interactive and can only interact when they flip flavours. Flavours are flipped when energy states change or travel mediums change (electron, muon and tau)(Ashfaque, 2015)



Possible Explanations - Dark Matter

Self-Interacting Dark Matter (Burne, 2018)

- Dark matter is made up of many kinds of particles instead of just one
- They interact with each other just like ordinary matter
- Analogous to a mirrored version of ordinary matter

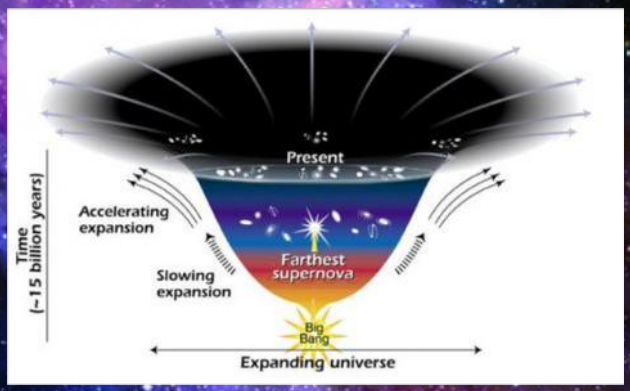
Kaluza-Klein Particle (Ashfaque, 2015)

- Precursor to string theory, based on an invisible 5th dimension
- Could interact via gravity and electromagnetism
- Decays into photons and neutrinos (yet to detect it in the LHC)

Possible Explanations - Dark Energy

Vacuum Energy (Einstein's Blunder) (Hobby-Eberly, 2015)(NASA, 2019)

- Also called the “cosmological constant”
- Space itself contains this energy and is being “pushed” or expanded by it. This energy is static, it is everywhere at all times and is not diluted by expanding space.
- Could explain the more “recent” phenomenon of universe expansion. This expansion has accelerated since the Big Bang, partly because this energy has taken over expansion since gravity has grown weaker as universe expands.



Possible Explanations - Dark Energy

Quintessence (Caldwell, 2000)(NASA, 2019)

- Proposed fifth fundamental force, along with Weak, Strong, Electromagnetic and Gravity.
- A dynamic force (changes over time) who's energy changes over time and space instead of being static which is the main difference between Vacuum Energy and Quintessence.
- Can be both attractive or repulsive depending on its ratio of kinetic and potential energy.

Uses and Applications

A brief reminder...

- It's worth mentioning that E=mc2
- While research is primarily focused on Dark Matter;
- Matter and energy are two sides of the same coin
  - Once the scientific community starts to understand one of these hypotheses, they can infer information about the other.

Uses and Applications

Dark energy making sci-fi real

- Studying gravitational lensing could lead to a better understanding of dark matter and energy
- Tamara Davis, Ph.D stated: "Dark energy seems to have repulsive gravity"
  - "If we can start to learn to control gravity we won't need rockets to get off earth

"Maybe we can make those hovering cars like in *Star Wars*." Tamara Davis Ph.D

Uses and Applications

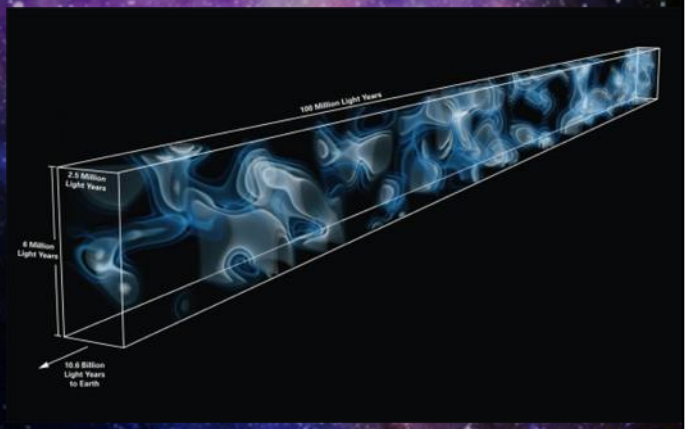
More sci-fi made science

- Without the need for rockets, space travel becomes MUCH easier
  - Physicists wouldn't have to fuss with shuttles reaching escape velocity
- Large pieces of equipment could easily be floated into space.
  - Not enough room on earth for a ludicrously sized particle accelerator? No problem! Just build it in space.

Uses and Applications

The cosmic web

- Picture the universe as a web
- When the cosmic web were very young, it was comprised of clumps and strands of dark matter
- These clumps of dark matter attracted matter and are the origin sights of galaxies
  - These clumps grow denser and more compact while dark energy simultaneously expands the web.



Uses and applications- Casey

The cosmic web

- A 3D map of the cosmic web has been made from a time where the universe was only 3 billion years old from a location 10.8 billion light years away
  - That's *basically* the awkward teenage years for the universe
- If this web can be studied, we can understand how dark matter and energy oppose each other

Uses and Applications

The Nihilistic outlook

- All this research could be for nothing
- As of august 14th, 2018 scientist are seriously questioning everything they thought they knew
- It's quite possible that dark matter could be confined to dimensions parallel to the third one we reside in

Conclusion

- Dark matter and dark energy raise some big questions in the study of space and physics.
- Scientists are using observations and math to figure out what these are. This will help us understand more about our amazing universe
  - However, it's entirely possible that we only gain a better understanding of what we don't understand