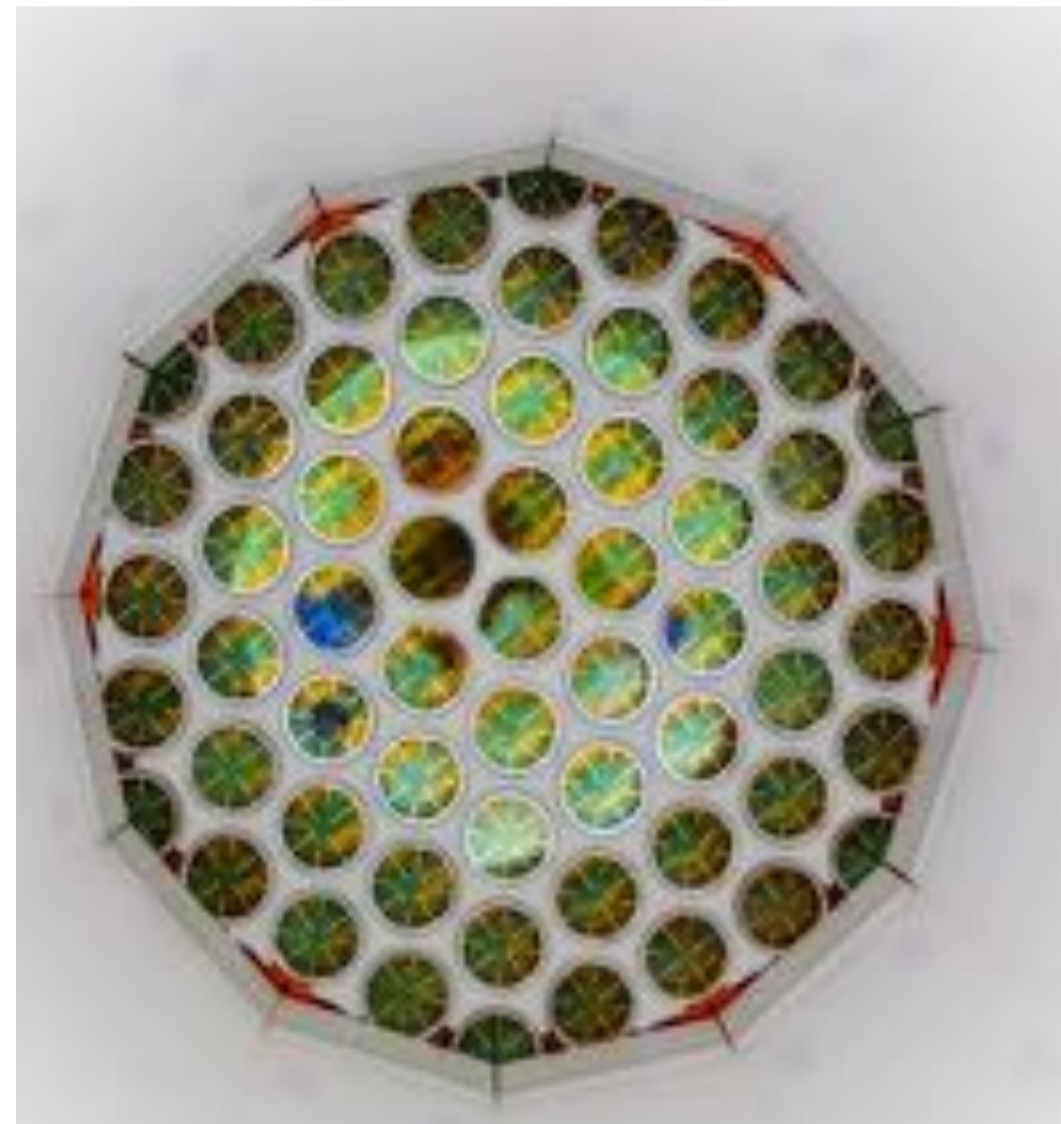
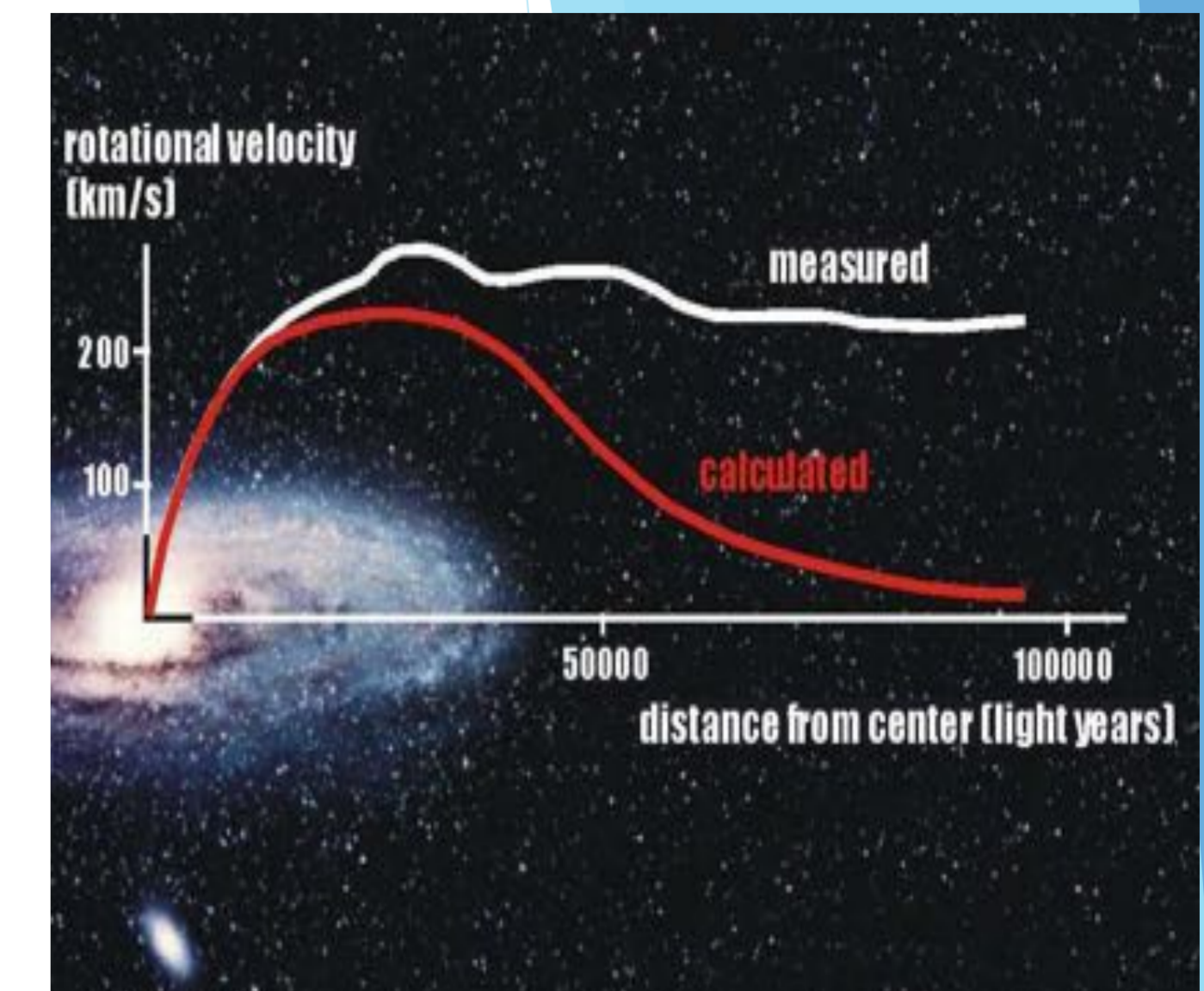


Dark matter has been proposed as an explanation for gravitational issues within the standard model of the universe. From observable matter, many galaxies should have long torn themselves apart as the measurable mass within is not enough to sustain the high speeds at which they spin. Dark matter would also account for anomalies observed in gravitational lensing (where light is distorted by gravity), such as the colliding galaxies of the bullet cluster. Dark matter would increase the gravitation in these situations as predicted by the standard model. Current theories suggest that dark matter could make up 26.8% of our universe (compared to normal matter only constituting 4.9%).

However dark matter has never been detected and scientists are still researching the possible models for it, and trying to find evidence of its existence. My research considers four proposals, and reviews any supporting experimental data.

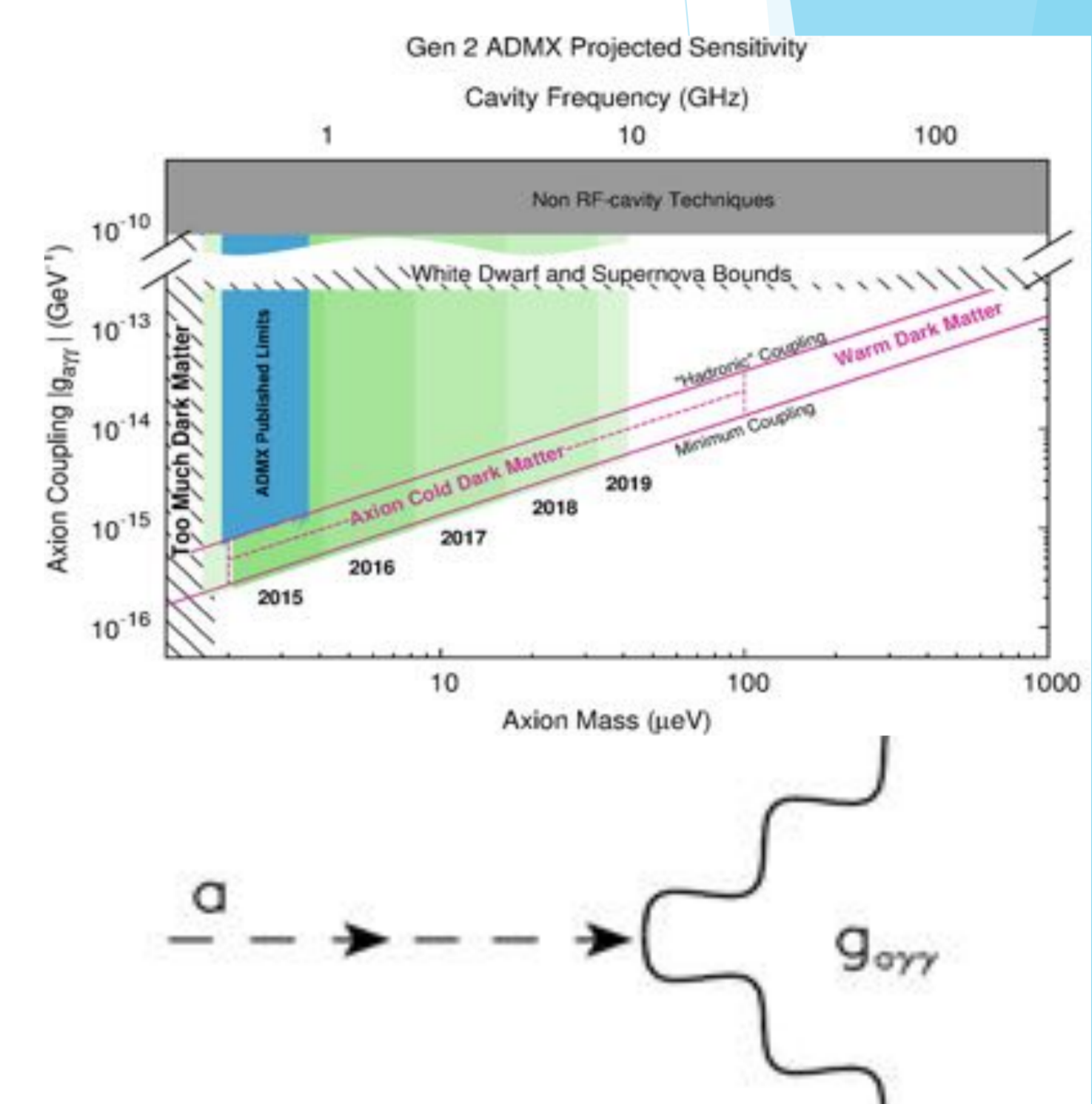


Weakly Interacting Massive Particles (WIMPs)

- WIMPs are theoretical particles that are the most popular candidate for dark matter.
- They would only interact through the weak nuclear force and gravity, and be very massive (with an energy of above 100 GeV, or of 100,000 protons).
- The Large Underground Xenon experiment (LUX) is looking for these very rare interactions with ordinary atomic nuclei, by measuring the disturbance they would make.
- It is 4.3 km below ground, and contains a cylinder of liquid Xenon that is monitored by a particle detector looking for these rare disturbances.
- LUX predicts that the next five to 10 years will provide conclusive evidence as to the existence of WIMPs.

Axions

- Axions are another possible particle for dark matter, but are much lighter being around 10^{-6} - 1 eV/c² or 500 million times lighter than an electron.
- Theory predicts they could have easily been created in vast amounts soon after the big bang.
- No evidence has been found outside theoretical predictions for axions, as they interact even more weakly with ordinary matter than WIMPs would.
- Experiments like ADMX (Axion Dark Matter eXperiment) are still ongoing to find them, by trying to detect the conversion of axions into photons.
- However the ADMX is currently undergoing an upgrade to use higher frequency detectors, and therefore be able to search for higher energy particles.



Primordial Black Holes

- Black holes are usually formed through stellar gravitational collapse, when a star runs out of hydrogen to use as fuel.
- Primordial black holes are smaller black holes that are predicted to have been formed seconds after the Big Bang, during the high-density, inconsistent phase, and not from stellar gravitational collapse.
- They were first proposed by Stephen Hawking in 1971. Gradually they were ruled out as a candidate after many observations from gravitational lensing suggested that not enough of the predicted mass could exist to constitute the dark matter in the universe.
- However, recent results from the Laser Interferometer Gravitational-Wave Observatory (LIGO) have detected gravitational waves from the violent merger of two black holes with the mass of 29 to 36 solar masses. This meant that black holes with an intermediate mass could exist, instead of there only being small stellar black holes and supermassive ones.
- It was then suggested that these larger primordial black holes could account for dark matter if they lay within faint dwarf galaxies and globular clusters (a compact sphere of mainly older stars), and therefore could not be seen from earth through lensing.

Strangelets

- Strangelets are massive theoretical particles made up of roughly equal amounts of down and strange quarks. The proposed size of strangelets is important as small strange particles (particles containing strange quarks), will decay via the weak force, losing their strangeness (a property affected by the number of strange quarks).
- A strangelet could range in size from a few femtometres (10^{-15} metres) to a macroscale star of quark matter, so they might not suffer from this instability. This is because as the surface tension between the quarks and the vacuum will be smaller with a larger particle, and so the chance of the particle fissioning is smaller.
- However experiments on earth cannot be carried out, as contact between strange matter and normal matter could result in an immediate conversion of the earth to strange matter within moments.
- So instead of trying to recreate strangelets on earth, scientists search for evidence of exotic cosmic rays from strangelets that have already decayed and lost their strangeness.

Conclusion

There are many more suggested models for dark matter, as I have only covered those most popular (because they fit the standard model). Another theory postulates that the cosmological anomalies are simply a fundamental part of the force of gravity, and not an additional particle. Scientists also theorise that dark matter could be explained by more than one of these models. This would reenergize the idea of primordial black holes, as a different particle could make up the other 65% of the dark matter. However this would contradict the WIMP miracle, where theorists calculated the number of WIMPs that would still exist since the Big Bang, and it corresponded exactly to the mass of the missing dark matter – meaning that no other particles could exist besides WIMPs. However, many experiments have found no conclusive evidence for WIMPs or Axions, so theorists may turn to another solution very soon.

