Gravitational lensing points to a candidate for lighter dark matter!

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Astrophysics

Preliminaries

- We still don't understand what dark matter is, despite the fact that it has been known for decades that the visible Universe rests on a foundation of dark matter.
- Numerous pieces of evidence suggest the existence of WIMPs — weakly interacting massive particles — on vast dimensions.
- Although decades of hunting for the particles have turned up nothing, there are a number of aspects that are difficult to explain using WIMPs.
- This leaves people open to the possibility that dark matter is made up of particles other than WIMPs.
- Axions, a force-carrying particle that was proposed to resolve an issue in a different branch of physics — strong CP problem, are one of the numerous contenders.
- Although they have other characteristics that are consistent with dark matter, they are far lighter than WIMPs, which has maintained a low degree of interest in them.
- This article makes the case that axion-like qualities provide the best explanation for several gravitational lens phenomena, which are mostly the result of dark matter.

Background galaxies that have been gravitationally lensed are represented by the red arcs to the right of the center. The distribution of dark matter in the foreground determines the quantity, position, and degree of distortion of these images.

Preliminaries

- WIMPs continue to provide a very good fit to the data on cosmological scales.
- There are some abnormalities, though, that don't quite make sense once you break things down to the level of individual galaxies, unless the dark matter halo encircling a galaxy has a complex structure.
- Similar phenomena appear to be true when attempting to map individual galaxies' dark matter based on that matter's capacity to bend space into a gravitational lens that enlarges and warps background objects.
- We may have predicted the existence of WIMPs based on the missing mass in particle colliders if they are Standard Model particles. No proof of that has been provided.
- This has led some people to reconsider whether WIMPs are the most effective way to deal with dark matter.

Preliminaries

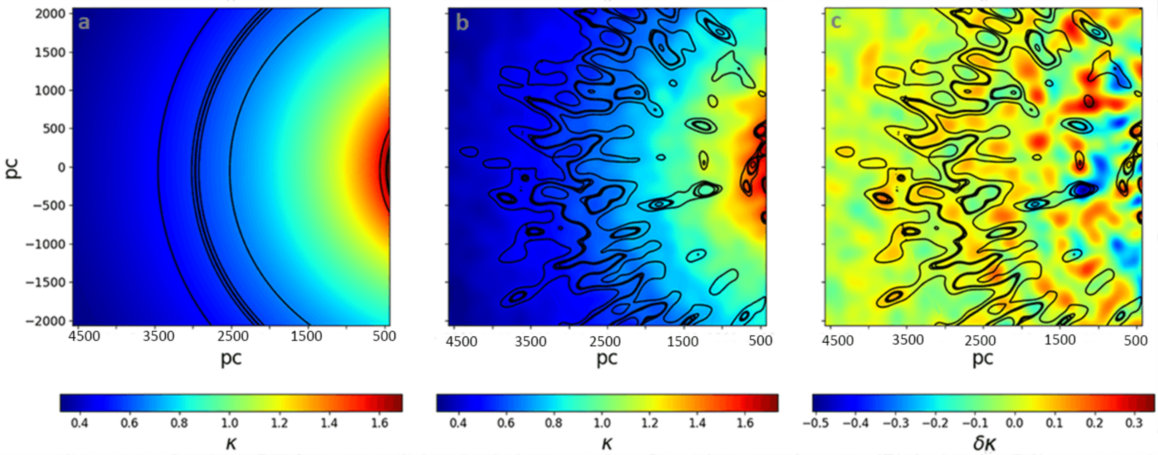
- The new research makes an effort to connect these conceivable anomalies to a distinction between the characteristics of WIMPs and axions.
- WIMPs should behave as distinct particles, as suggested by their name, interacting primarily through gravity.
- A galaxy should see wave-like patterns in the frequency of axions, which interact with one another through quantum interference.
- Therefore, although WIMP frequency should gradually decrease as one moves away from a galaxy's center, axions frequency should increase when they create a standing wave (technically a soliton) close to the galactic centre.
- Complex interference patterns at a greater distance should produce regions where axions are practically absent and others where they are twice as dense.

Hard to spot

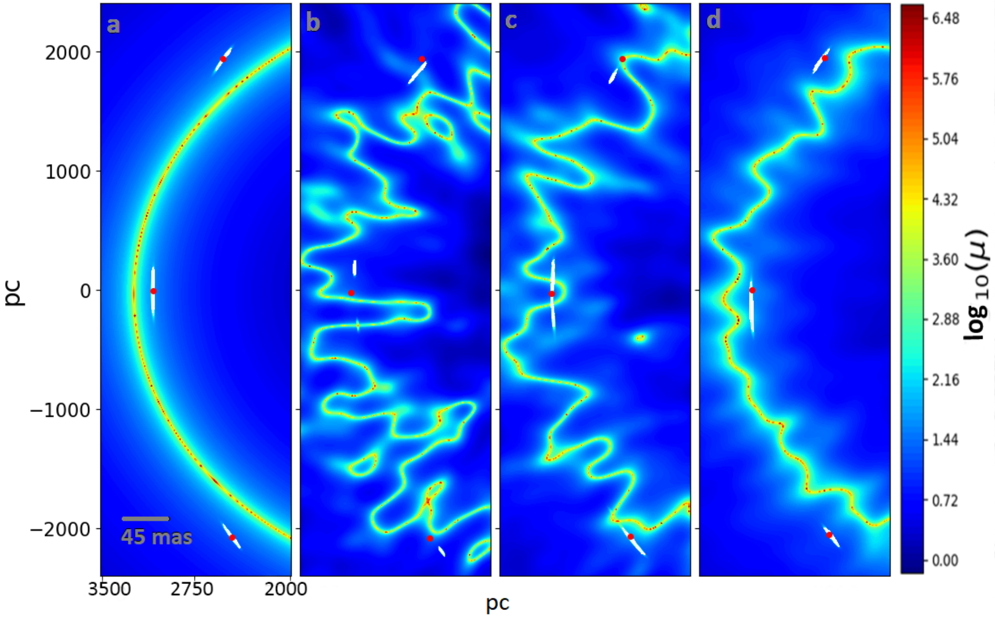
- According to modeling, minute variations are so subtle that even the Hubble Space Telescope couldn't detect them.
- But by integrating the information from numerous radio telescopes that are located far apart, it might be able to find them at radio wavelengths.
- And we have that information in at least one instance. Between us and an active black hole in the center of another galaxy, HS 0810+2554 is a large elliptical galaxy.
- Four pictures of the active galaxy are formed by the gravitational lens produced by the galaxy in the foreground, each of which features a brilliant galactic nucleus and two sizable material jets emanating from it. These four photos' positions and distortions can be compared to what we could anticipate if the foreground galaxy contained a normal dark matter halo.
- Since there is only one pattern we would anticipate — the slow decline in dark matter levels as you approach away from the galactic core — it is pretty easy to do with the WIMPs.

Hard to spot

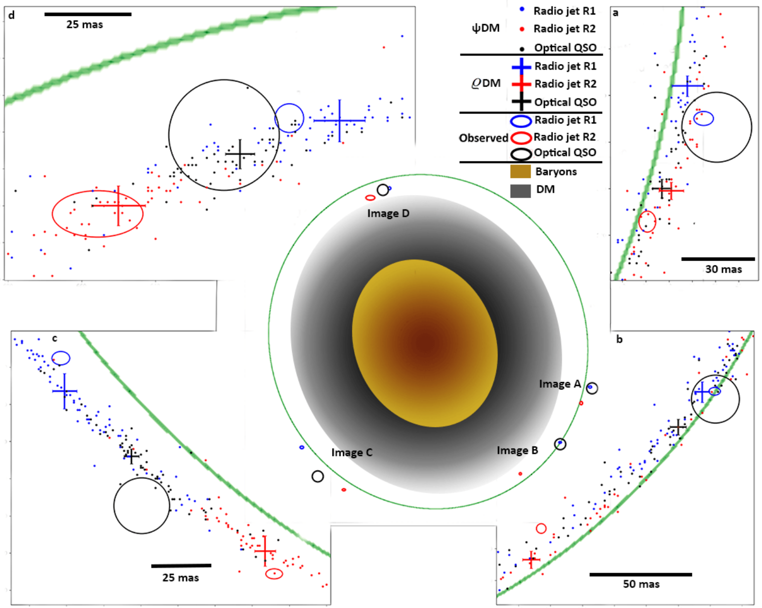
- Finally, axions with an electronVolts of 10^{-22} are required for this type of interference pattern to function. In contrast, the mass of one electron is around $500,000$ electronVolts.
- The axions could then become far lighter than even neutrinos as a result of this.



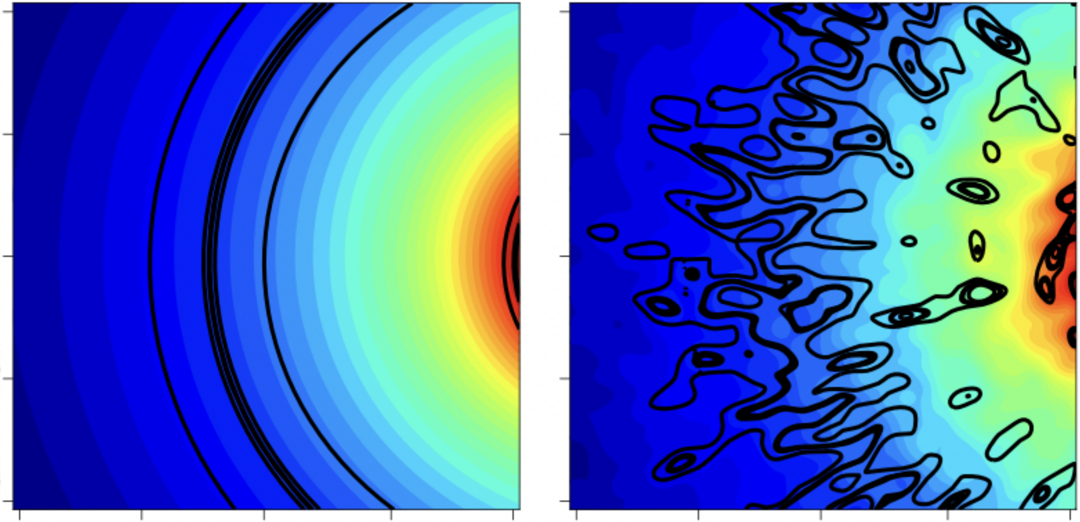
Iso-magnification contours of ψDM versus ϱDM halos.



Lensing Magnification of ψDM versus ϱDM halos.



ψDM versus ϱDM model predictions for HS 0810+2554.



WIMP-based dark matter, modeled at left, leads to a smooth distribution from high (red) to low (blue) as you move farther from a galaxy's core. With axions (right), quantum interference creates a far more irregular pattern.