Serious blow to dark matter theories? New study finds mysterious lack of dark matter in Sun's neighborhood

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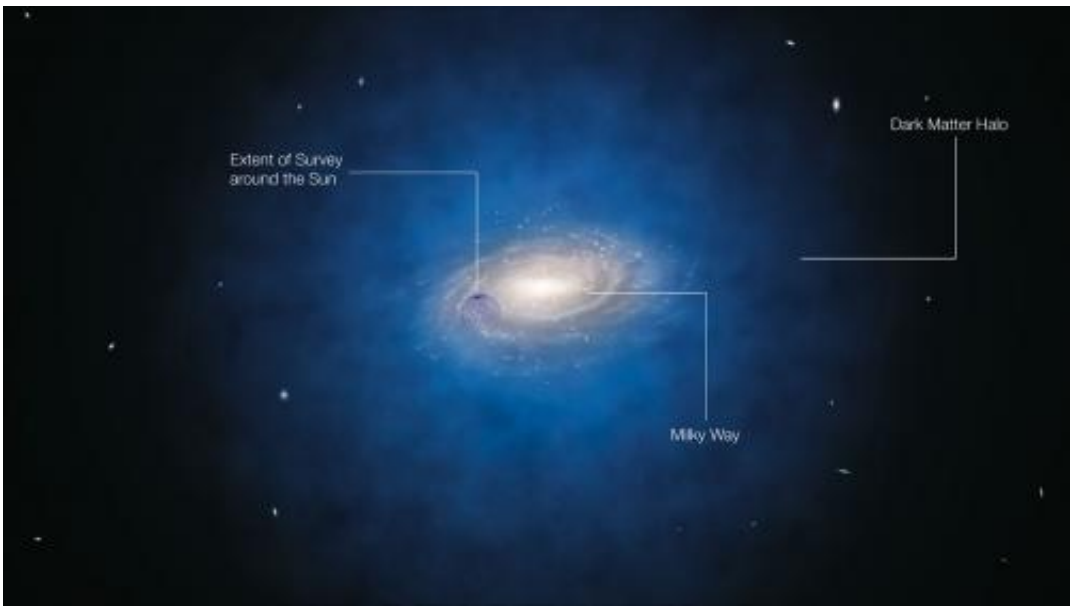

This annotated artist's impression shows the Milky Way galaxy. The blue halo of material surrounding the galaxy indicates the expected distribution of the mysterious dark matter. New measurements based on the movements of stars show that the amount of dark matter in this region around the Sun is far smaller than predicted and have indicated that there is no significant dark matter at all in our neighbourhood. The blue sphere centred on the Sun's position shows the approximate size of the newly surveyed volume, but not its precise shape. Credit: ESO/L. Calçada

(Phys.org) -- The most accurate study so far of the motions of stars in

the Milky Way has found no evidence for dark matter in a large volume around the Sun. According to widely accepted theories, the solar neighbourhood was expected to be filled with dark matter, a mysterious invisible substance that can only be detected indirectly by the gravitational force it exerts. But a new study by a team of astronomers in Chile has found that these theories just do not fit the observational facts. This may mean that attempts to directly detect dark matter particles on Earth are unlikely to be successful.

A team using the MPG/ESO 2.2-metre telescope at ESO's La Silla Observatory, along with other telescopes, has mapped the motions of more than 400 stars up to 13 000 light-years from the Sun. From this new data they have calculated the mass of material in the vicinity of the Sun, in a volume four times larger than ever considered before.

"The amount of mass that we derive matches very well with what we see — stars, dust and gas — in the region around the Sun," says team leader Christian Moni Bidin (Departamento de Astronomia, Universidad de Concepcion, Chile). "But this leaves no room for the extra material — dark matter — that we were expecting. Our calculations show that it should have shown up very clearly in our measurements. But it was just not there!"

Dark matter is a mysterious substance that cannot be seen, but shows itself by its gravitational attraction for the material around it. This extra ingredient in the cosmos was originally suggested to explain why the outer parts of galaxies, including our own Milky Way, rotated so quickly, but dark matter now also forms an essential component of theories of how galaxies formed and evolved.

Today it is widely accepted that this dark component constitutes about the 80% of the mass in the Universe [1], despite the fact that it has resisted all attempts to clarify its nature, which remains obscure. All

attempts so far to detect dark matter in laboratories on Earth have failed.

By very carefully measuring the motions of many stars, particularly those away from the plane of the Milky Way, the team could work backwards to deduce how much matter is present [2]. The motions are a result of the mutual gravitational attraction of all the material, whether normal matter such as stars, or dark matter.

Astronomers' existing models of how galaxies form and rotate suggest that the Milky Way is surrounded by a halo of dark matter. They are not able to precisely predict what shape this halo takes, but they do expect to find significant amounts in the region around the Sun. But only very unlikely shapes for the dark matter halo — such as a highly elongated form — can explain the lack of dark matter uncovered in the new study [3].

The new results also mean that attempts to detect dark matter on Earth by trying to spot the rare interactions between dark matter particles and "normal" matter are unlikely to be successful.

"Despite the new results, the Milky Way certainly rotates much faster than the visible matter alone can account for. So, if dark matter is not present where we expected it, a new solution for the missing mass problem must be found. Our results contradict the currently accepted models. The mystery of dark matter has just become even more mysterious. Future surveys, such as the ESA Gaia mission, will be crucial to move beyond this point." concludes Christian Moni Bidin.

More information: This research was presented in a paper, "Kinematical and chemical vertical structure of the Galactic thick disk II. A lack of dark matter in the solar neighborhood", by Moni-Bidin et al. to appear in *The Astrophysical Journal.*

Notes

[1] According to current theories dark matter is estimated to constitute 83% of the matter in the Universe with the remaining 17% in the form of normal matter. A much larger amount of dark energy also seems present in the Universe, but is not expected to affect the motions of the stars within the Milky Way.

[2] The observations were made using the FEROS spectrograph on the MPG/ESO 2.2-metre telescope, the Coralie instrument on the Swiss 1.2-metre Leonhard Euler Telescope, the MIKE instrument on the Magellan II Telescope and the Echelle Spectrograph on the Irene du Pont Telescope. The first two telescopes are located at ESO's La Silla Observatory and the latter two telescopes are located at the Las Campanas Observatory, both in Chile. A total of more than 400 red giant stars at widely differing heights above the plane of the galaxy in the direction towards the south galactic pole were included in this work.

[3] Theories predict that the average amount of dark matter in the Sun's part of the galaxy should be in the range 0.4-1.0 kilograms of dark matter in a volume the size of the Earth. The new measurements find 0.00±0.07 kilograms of dark matter in a volume the size of the Earth.

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