Three dwarf spheroidal galaxies found to rotate

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Fornax dwarf spheroidal galaxy. Credit: ESO/Digitized Sky Survey 2.

An international team of astrophysicists from the Instituto de Astrofísica de Canarias (IAC), the University of La Laguna (ULL) and the Space Telescope Science Institute (STScI, U.S.) has discovered the presence of transverse rotation (in the plane of the sky) in three dwarf spheroidal galaxies. These are a very faint type of galaxy and are quite difficult to observe. These new findings help to trace their evolutionary history. The finding was made using the most recent data from the GAIA satellite of the European Space Agency. The results of the study have just been published in the journal *Monthly Notices of the Royal Astronomical Society* (*MNRAS*).

Dwarf galaxies have a particular interest for cosmology. The standard cosmological model suggests that this type of galaxy was the first to form. Most of them have been destroyed and cannibalized by large galaxies such as the Milky Way. However, those that remain can be studied and contain valuable information about the early Universe.

One subclass of dwarf galaxies are the dwarf spheroidals. They are very diffuse, with low luminosity, and contain large proportions of dark matter with little or no gas. Since their discovery, they have been deeply studied. However, their internal kinematics are still little known, due to the technical difficulties involved in detailed study of their mechanics.

Various previous studies have shown that the dwarf spheroidals do not have patterns of internal rotation, but that their stars move on random orbits predominantly towards and away from the center of the galaxy. The other major sub-class of dwarfs—the irregulars—have large quantites of gas, and in some cases do have internal rotation. These

differences suggest a different origin for the two types of dwarfs, or at least a very different evolutionary history in which interactions with large galaxies, in our case with the Milky Way, have played a crucial role in eliminating the internal rotation of the spheroidals.

To carry out their present research, the team of astrophysicists form the IAC and the STScI have used the latest data from ESA's Gaia to study the internal kinematics of six dwarf spheroidal galaxies, satellites of the Milky Way, and have discovered the presence of transverse rotation (in the plane of the sky) in three of them: Carina, Fornax, and Sculptor. These are the first detections of this type of rotation in dwarf spheroidal galaxies, except for the Sagittarius spheroidal, which is strongly distorted by the gravitational potential of the Milky Way, and is therefore not representative of its type.

"The importance of this result is because, in general, the internal kinematics of galaxies, in this case their rotation, is an important tracer of their evolutionary history, and of the conditions in which the system was formed", explains Alberto Manuel Martínez-García, doctoral student at the IAC and the ULL, and first author of the article.

"Although the standard model of cosmology assumes that the dwarf galaxies were the first to form, it is not clear if they are simple systems or whether those we observe are formed by the agglomeration of other even simpler systems, smaller and older. The presence of rotation suggests the second option. It also suggests a common origin for all dwarf galaxies, those that are at present rich in gas (the irregulars) and those which are not (the spheroidals)", explains Andrés del Pino, researcher at the STScI and a co-author of the article.

"The Gaia satellite has revolutionized our knowledge of the Milky Way and its neighborhood, giving us very precise measurements of the positions and motions of almost two thousand million stars. Although the

data from Gaia are used mainly to study our Galaxy, this ESA mission has also opened a new window on the study of the satellite galaxies of the Milky Way, giving specific access to their internal kinematics", says Antonio Aparicio, a researcher at the IAC and the ULL and a co-author of the article.

Even so, according to the researchers, studies based on Gaia data entail many technical difficulties. In the first place, one must determine which of the stars in the database really belong to the satellite galaxies, and which to the Milky Way itself, as the latter tend to contaminate the sample. The problem is that although the data to be analyzed are limited to the region and the angular size of the spheroidal under study, which is the equivalent of one quarter of the angular diameter of the Moon, the vast majority of the stars detected in this area belong to the Milky Way and therefore indeed contaminate the sample.

In addition, the distance of the spheroidals studied, which is up to some half a million light-years, and the low intrinsic luminosity of their stars, imply that the measurements are affected by a considerable level of noise. For all these reasons the analysis of the data requires a thorough filtration and a deep analysis of the different observational parameters to be able to reach reliable conclusions.

More information: Alberto Manuel Martínez-García et al, Internal rotation of Milky Way dwarf spheroidal satellites with Gaia Early Data Release 3, *Monthly Notices of the Royal Astronomical Society* (2021). DOI: 10.1093/mnras/stab1568

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