

Media Release

TUESDAY, 5 FEBRUARY 2019



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The Milky Way is warped

The first accurate 3D map of our galaxy reveals its true shape: warped and twisted.

Astronomers from Macquarie University and the Chinese Academy of Sciences have used 1339 'standard' stars to map the real shape of our home galaxy in a paper published in *Nature Astronomy* today.

They found the Milky Way's disc of stars becomes increasingly 'warped' and twisted the further away the stars are from the galaxy's centre.

"We usually think of spiral galaxies as being quite flat, like Andromeda which you can easily see through a telescope," says Professor Richard de Grijs, a co-author and astronomer from Macquarie University in Sydney, Australia.

Trying to determine the real shape of our galaxy is like standing in a Sydney garden and trying to determine the shape of Australia. But, for the past 50 years there have been indications that the hydrogen clouds in the Milky Way are warped. The new map shows that the warped Milky Way disc also contains young stars. It confirms that the warped spiral pattern is caused by torque from the spinning of the Milky Way's massive inner disc of stars.

"It is notoriously difficult to determine distances from the Sun to parts of the Milky Way's outer gas disc without having a clear idea of what that disc actually looks like," says Xiaodian Chen, lead author, from the Chinese Academy of Sciences in Beijing.

"This research provides a crucial updated map for studies of our galaxy's stellar motions and the origins of the Milky Way's disk," says Licai Deng, senior researcher at the Chinese Academy of Sciences and co-author on the paper.

The team built their map using 1339 large pulsating stars each up to 100,000 brighter than our sun. Data on these classical Cepheid stars were provided by the Wide-field Infrared Survey Explorer (WISE).

Astronomers have observed a dozen other galaxies which showed similar progressively twisted spiral patterns in their outer regions. So our Milky Way's twists are rare but not unique.

Macquarie University astronomer Professor Richard de Grijs is available for interviews +61-466-336-588, richard.de-grijs@mq.edu.au



A slightly exaggerated impression of the real shape of our warped and twisted Milky Way. Image: Chao Liu (National Astronomical Observatories, Chinese Academy of Sciences)

Media Contacts:

- Suzannah Lyons, +61-409-689-543, suzannah@scienceinpublic.com.au
- MQ contact Lucy Mowat, +61-(2)-9850-1055, lucy.mowat@mq.edu.au

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Backgrounder

The Milky Way's disc of stars becomes increasingly 'warped' and twisted the further away they are from the galaxy's centre, according to astronomers from Macquarie University and the Chinese Academy of Sciences in a paper published in *Nature Astronomy* today.

From a great distance, our spiral galaxy would look like a thin disc of stars that orbits once every few hundred million years around its central region, where hundreds of billions of stars provide the gravitational 'glue' to hold it all together.

But this pull of gravity is much weaker in the galaxy's far outer disc. There, the hydrogen atoms making up most of the Milky Way's gas disc are no longer confined to a thin plane, instead they give the disc an S-like, or warped, appearance.

The researchers were able to determine our galaxy's twisted appearance after they developed the first accurate three-dimensional picture of the Milky Way out to its far outer regions.

"It is notoriously difficult to determine distances from the Sun to parts of the Milky Way's outer gas disc without having a clear idea of what that disc actually looks like," says Xiaodian Chen, a researcher at the Chinese Academy of Sciences in Beijing and lead author of the article.

"However, we recently published a new catalogue of well-behaved variable stars known as classical Cepheids, for which very accurate distances can be determined with an error of only three to five per cent."

Classical Cepheids are young stars that are some four to 20 times as massive as our Sun and up to 100,000 times as bright.

Such high stellar masses imply that they live fast and die young, burning through their fuel very quickly, sometimes in only a few million years.

They show day- to month-long pulsations, which are observed as changes in their brightness. Combined with a Cepheid's observed brightness, its pulsation period can be used to obtain a highly accurate distance.

"Somewhat to our surprise, we found that in 3D our collection of 1339 Cepheid stars and the Milky Way's gas disc follow each other closely. This offers new insights into the formation of our home galaxy," says Macquarie University's Professor Richard de Grijs, senior co-author on the paper.

"Perhaps more importantly, in the Milky Way's outer regions, we found that the S-like stellar disc is warped in a progressively twisted spiral pattern."

Astronomers have observed a dozen other galaxies which showed similar patterns.

Combining their results with these earlier observations, the researchers concluded that the Milky Way's warped spiral pattern is most likely caused by torque from the galaxy's massive inner disc.

"This new morphology provides a crucial updated map for studies of our galaxy's stellar motions and the origins of the Milky Way's disc," says Licai Deng, senior researcher at the Chinese Academy of Sciences and co-author on the paper.

Chen X, Wang S, Deng L, de Grijs R, Lui C & Tian H. [An intuitive 3D map of the Galactic warp's precession traced by classical Cepheids](#). *Nature Astronomy*. February 2019.

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Abstract

An intuitive 3D map of the Galactic warp's precession traced by classical Cepheids

The Milky Way's neutral hydrogen (H i) disk is warped and flared^{1,2}. However, a dearth of accurate H i-based distances has thus far prevented development of an accurate Galactic Disk model. Moreover, the extent to which our Galaxy's stellar and gas disk morphologies are mutually consistent is also unclear. Classical Cepheids, primary distance indicators with distance accuracies of 3–5% (ref. ³), offer a unique opportunity to develop an intuitive and accurate three-dimensional picture. Here, we establish a robust Galactic Disk model based on 1,339 classical Cepheids. We provide strong evidence that the warp's line of nodes is not oriented in the Galactic Centre–Sun direction. Instead, it subtends a mean angle of $17.5^\circ \pm 1^\circ$ (formal) $\pm 3^\circ$ (systematic) and exhibits a leading spiral pattern. Our Galaxy thus follows Briggs' rule for spiral galaxies⁴, which suggests that the origin of the warp is associated with torques forced by the massive inner disk⁵. The stellar disk traced by Cepheids follows the gas disk in terms of their amplitudes; the stellar disk extends to at least 20 kpc (refs. ^{6,7}). This morphology provides a crucial, updated map for studies of the kinematics and archaeology of the Galactic Disk.

Authors

Xiaodian Chen¹, Shu Wang², Licai Deng^{1,3}, Richard de Grijs^{4,5,6}, Chao Liu¹ and Hao Tian¹

Affiliations

- 1 Key Laboratory for Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China.
- 2 Kavli Institute for Astronomy and Astrophysics, Peking University, Beijing, China.
- 3 Department of Astronomy, China West Normal University, Nanchong, China.
- 4 Department of Physics and Astronomy, Macquarie University, Sydney, New South Wales, Australia.
- 5 Research Centre for Astronomy, Astrophysics and Astrophotonics, Macquarie University, Sydney, New South Wales, Australia.
- 6 International Space Science Institute–Beijing, Beijing, China.

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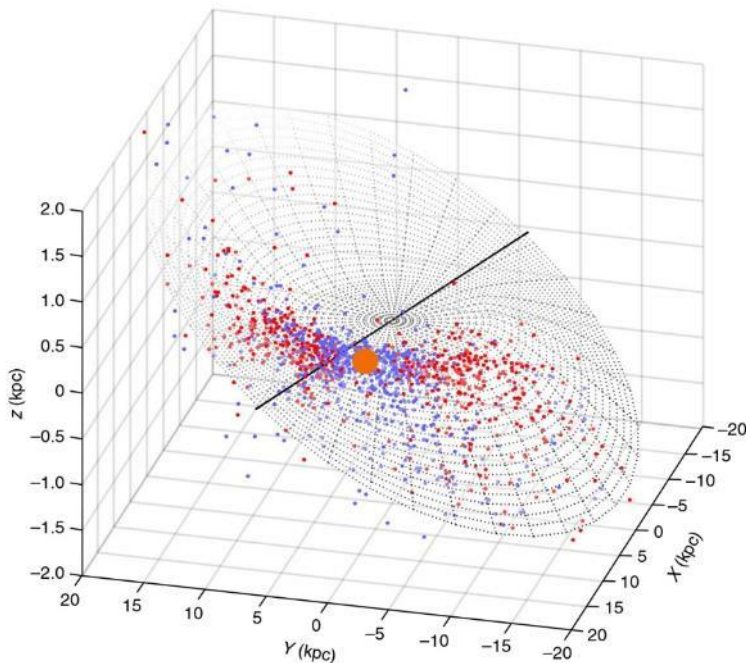
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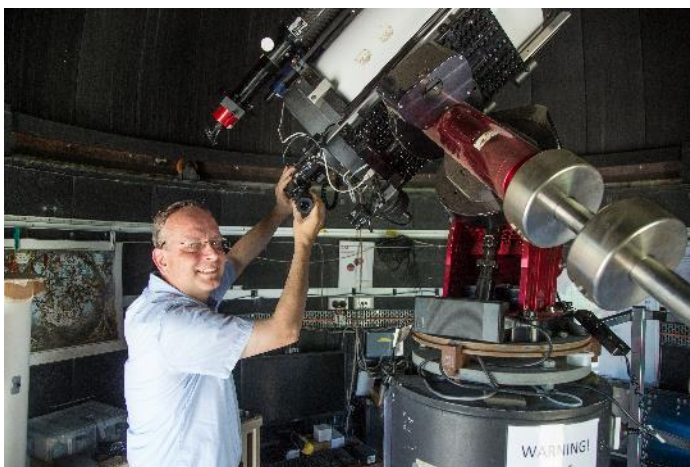
Further images and links



3D distribution of the classical Cepheid variable stars in the Milky Way's warped disc (red and blue points) centred on the location of the Sun (shown as a large orange symbol).

The units 'kpc' (kiloparsecs) along the image's three axes are used by astronomers to indicate distances on galaxy-wide scales. One kiloparsec is equivalent to about 3,262 light years.

See an online video of this 3D map at: www.scienceinpublic.com.au/media-releases/milky-way (password: warped).



Professor Richard de Grijs (Macquarie University)

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The galaxy ESO 510-G13 is an edge-on warped spiral galaxy. Similar to the Milky Way it has a pronounced warp in its gaseous disc and a less pronounced warp in its disc of stars. (NASA/Space Telescope Science Institute)

- [The Young Stars Cluster Group, Kavli Institute for Astronomy and Astrophysics](#)
- [Professor Richard de Grijs' Macquarie University profile](#)
- [Department of Physics and Astronomy, Macquarie University](#)
- [Research Centre for Astronomy, Astrophysics and Astrophotonics, Macquarie University](#)
- [Wide-field Infrared Survey Explorer \(WISE\)](#)

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