Academia Sinica Press Release

Astrophysicists Illuminate Shape of Dark Matter's Distribution

Dark matter is an enigma of the cosmos that has fascinated astrophysicists for many years. The existence of dark matter was originally hypothesized to account for discrepancies found between measurements of the mass of galaxies, clusters of galaxies and the entire Universe; however, as dark matter is invisible and no "dark matter particle" has yet been discovered, the existence of dark matter can currently only be inferred from gravitational effects on other visible celestial matter, or theoretical models. Recently an international team of astrophysicists including Postdoctoral Fellow Dr. Nobuhiro Okabe from the Institute of Astronomy and Astrophysics at Academia Sinica (ASIAA) have collected direct, clear evidence that dark matter is distributed in an elliptic shape in massive clusters of galaxies, a finding that confirms a major prediction of the prevailing theory about dark matter. Their research was published online in "Monthly Notices of the Royal Astronomical Society", a leading astrophysics journal, on April 23, 2010.

The scientists conducted their research using a powerful technique called gravitational lensing and made detailed measurements of the spatial distributions of dark matter in 25 massive clusters of galaxies. Clusters of galaxies are ideal sites for studying the distribution of dark matter because they contain thousands of galaxies and are known to be accompanied by a large amount of dark matter. The team observed the clusters of galaxies using the Subaru Telescope's Prime Focus Camera (Suprime-Cam). Observations with Suprime-Cam yielded wide-field images of massive clusters of galaxies (typically located at 3 billion light years from the Earth), which the team then used to measure and analyze dark matter distributions.

From their detailed analysis of the images, the team obtained clear evidence that the distribution of dark matter in the clusters has, on average, an extremely flattened shape rather than a simple spherical shape. The degree of the flattening was quite large, corresponding to ratio of 2:1 in terms of the ratio of the major to minor axes of the ellipse. This finding represents the first direct and clear evidence of flattening in dark matter distribution and agrees with prevailing theory for dark matter distributions in clusters of galaxies which predicts that dark matter distribution in clusters of galaxies is non-spherical, reflecting a large-scale structure of dark matter filaments.

In addition to Dr. Okabe, the research team consisted of Dr. Masamune Oguri from the National Astronomical Observatory of Japan and Stanford University, Dr. Masahiro Tanaka from the University of Tokyo, and Dr. Graham Smith from the School of Physics and Astronomy at the University of Birmingham in the U.K.

The study was a part of the Local Cluster Substructure Survey (LoCuSS), an international project carrying out a systematic study of galaxy clusters by combining data from the Subaru telescope with a wide range of data sets from radio, infrared, optical and X-ray telescopes. The goal of the project is to reveal new aspects of cluster physics and cosmology.

The full article entitled “Direct measurement of dark matter halo ellipticity from two-dimensional lensing shear maps of 25 massive clusters” is available at the in “Monthly Notices of the Royal Astronomical Society” website at: http://www3.interscience.wiley.com/journal/123375492/abstract.

The full list of authors is: Masamune Oguri, Masahiro Takada, Nobuhiro Okabe and Graham P. Smith.

Media contacts:

Dr. Yao-Huan Tseng, Institute of Astronomy and Astrophysics, Academia Sinica Email: yhtseng@asiaa.sinica.edu.tw (Tel) +886-2-23665458

Fang-Hsun Yeh, Public Relations Office, Central Office of Administration, Academia Sinica (Tel) +886-2-2789-8820, (Fax) +886-2-2782-1551, (M) 0922-036-691

Email: hongsum@gate.sinica.edu.tw

Mei-Hui Lin, Public Relations Office, Central Office of Administration, Academia Sinica (Tel) +886-2-2789-8821, (Fax) +886-2-2782-1551, (M) 0921-845-234

Email: mhlin313@gate.sinica.edu.tw

IMAGES:

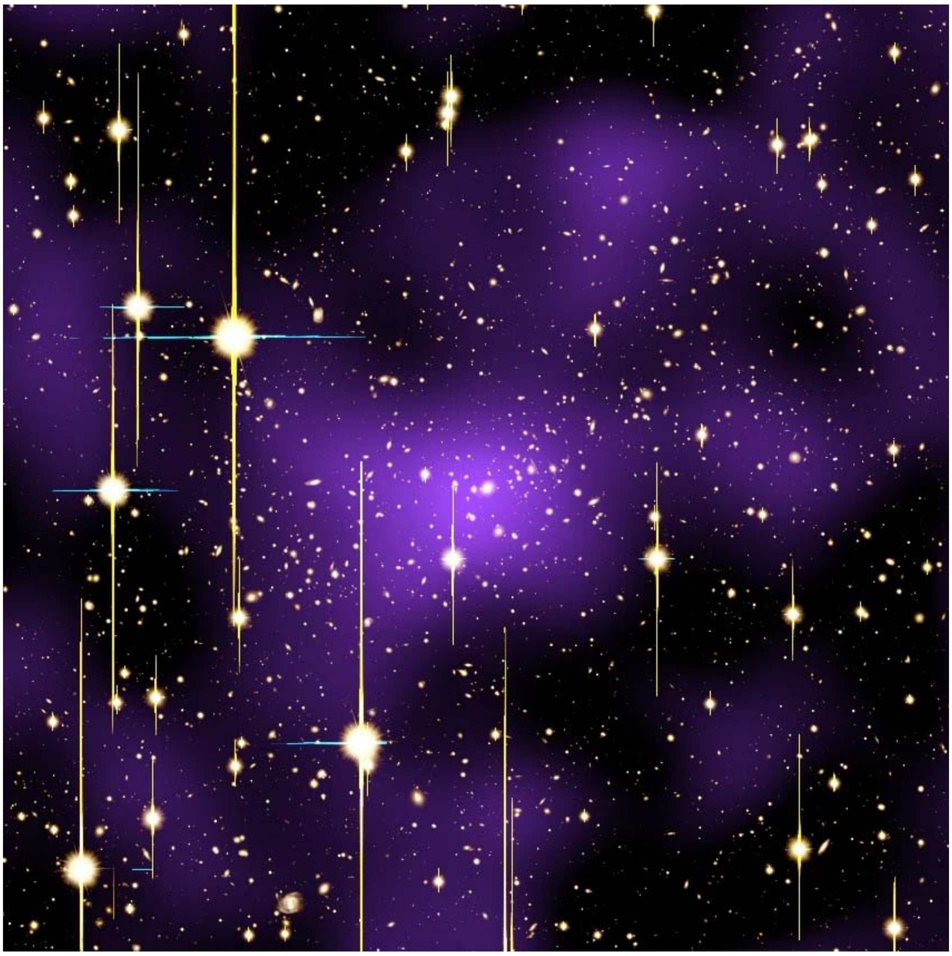

Figure 1: A Subaru Suprime-Cam image of one of the clusters used in the analysis, A2390, (2.7 billion light years from the Earth). The purple hue shows the dark matter distribution measured by the gravitational lensing effect on distant galaxies (typically 8 billion light years from the Earth) where the darker color indicates the denser dark matter concentration. It shows that the dark matter distribution is elongated along the northwest-southeast direction.

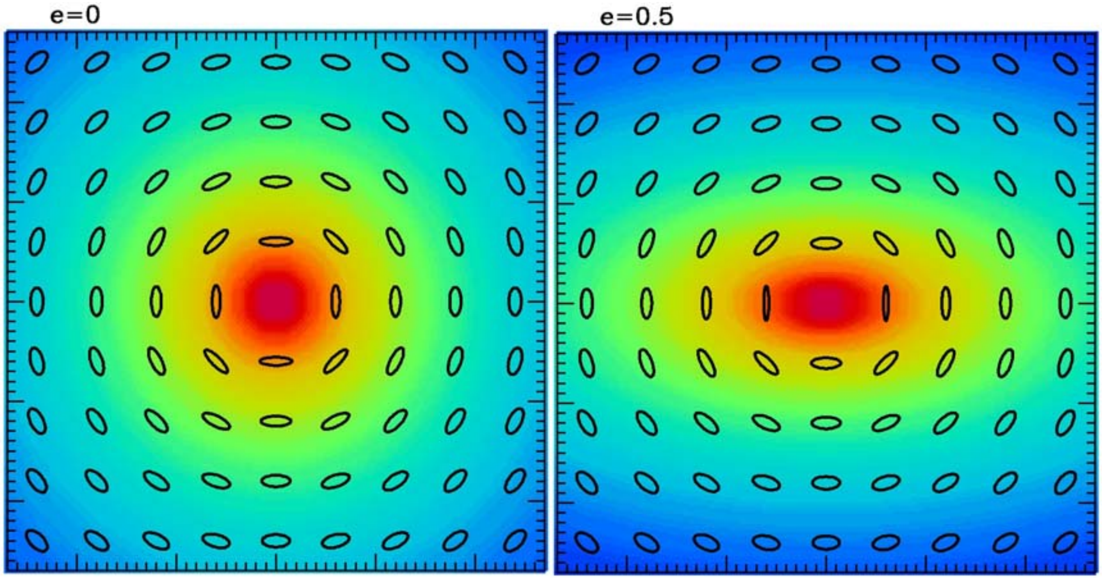

Figure 2: An illustration of the measurement of the dark matter distribution using gravitational lensing. The color contours indicate the density of dark matter, with redder color marking higher density. Black ellipses show the distortion pattern of background galaxies; positions of distant galaxies are systematically distorted into the shapes shown by black ellipses due to the gravitational lensing effect. (In practice, background galaxies have their own shapes and orientations, and hence many galaxies' shapes were averaged to extract distortions by gravitational lensing). Left and right panels show spherical and elliptical distributions of dark matter respectively. The difference in the distortion patterns suggests that one can measure the shape of the dark matter distribution from two-dimensional lensing distortion patterns.