中央研究院新聞稿

天文研究團隊重要發現
捕捉到宇宙最大結構體成長的瞬間

宇宙中有各種大小不同的天體系統，而「星系團(galaxy clusters)」是其中最巨大的一種。本院天文及天文物理研究所博士後研究員岡部信広博士(Dr. Nobuhiro Okabe)與天文所副研究員梅津敬一博士(Dr. Keiichi Umetsu)，日前參與一組包括日本理化學研究所（Institute of Physical and Chemical Research, RIKEN）在內的研究團隊，首度捕捉到「星系團」成長的瞬間。該篇論文將於2010年4月9日刊登於天文物理學刊(Astrophysical Journal)的網站上。

「星系團」的組成成員，包含數百到數千個星系、會發出 X 射線的高溫氣體以及「暗物質(dark matter)」。研究團隊展示了編號為 Abell 1689 的「星系團」戲劇性成長的瞬間影像。研究發現，「星系團」會藉由加熱而成長，而觸發加熱機制的，是氣體掉入「星系團」內所產生的能量，至於這些氣體的來源，則是位於「星系團」外，被稱為「宇宙網」的細絲狀「大尺度結構(large-scale structure)」。

首先，研究團隊利用日本的「朱雀號」X 射線觀測衛星(Suzaku X-ray satellite)，對位於 Abell 1689「星系團」最外圍的高溫氣體進行溫度測量，結果發現高溫氣體存在一個各向異性的溫度分布，該分布顯示，某個特定方向上的溫度，高達 5800 萬度，而其他方向上則僅有 2300 萬度。接著，研究團隊將 X 光波段輻射的數據與「Sloan 數位巡天計畫 (Sloan Digital Sky Survey, SDSS)」的資料做比對；其結果顯示，與溫度較高氣體相連接的，是位於「星系團」外的細絲狀「大尺度結構」，相對地，與溫度較低氣體相連接的，則是只含少數星系的區域。研究團隊也將 X 光波段輻射的數據，與取自日本「昴宿望遠鏡」(Japanese Subaru telescope)和「哈柏太空望遠鏡(Hubble Space Telescope)」的「重力透鏡」(gravitational lensing)觀測數據做比對，結果發現：這些溫度較低的氣體，其運動的速度應是低於音速的。整體而言，研究團隊透過整合 X 射線觀測、可見光觀測與重力透鏡數據的分析，首次捕捉到了「星系團」戲劇性成長的瞬間，說明了鑲嵌著這個星系團的「大尺度結構」會影響星系團的成長。

「朱雀號」衛星是日本第五個 X 射線天文台，其管理工作由「日本宇宙航空研究開發機構(Japan Aerospace Exploration Agency，簡稱 JAXA) 」負責，而儀器研發工作則由數個日本研究機構與「美國航太總署 Goddard 太空飛行中心(NASA Goddard Space Flight Center，簡稱 GSFC)」共同合作。

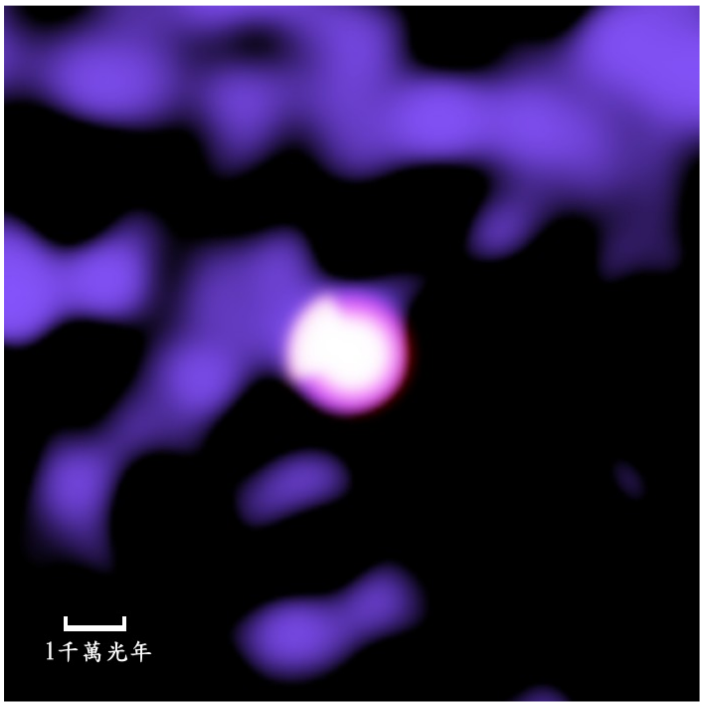
岡部信広博士2009年起於本院天文及天文物理研究所進行博士後研究，研究領域包括星系團、弱重力透鏡效應、X光與可見光波段數據分析及電漿物理學。梅津敬一博士是天文所副研究員，其主要研究領域為星系團，特別是在強重力透鏡和

弱重力透鏡效應上；2001年加入本院「宇宙微波背景輻射陣列」（AMiBA）研究團隊迄今。

研究團隊的其他成員，來自日本各大研究單位，包括：理化學研究所(The Institute of Physical and Chemical Research，簡稱 RIKEN)、東北大學天文所(Astronomical Institute, Tohoku University)、 山形大學物理系(Department of Physics, Yamagata University)、東京理科大學物理系(Department of Physics, Tokyo University of Science)、廣島大學物理科學系(Department of Physical Science, Hiroshima University)、日本國家天文台(National Astronomical Observatory of Japan)、東京大學物理系(Department of Physics, The University of Tokyo)、東京都立大學物理系(Department of Physics, Tokyo Metropolitan University) 。

本論文將以「Suzaku Observation of Abell 1689: Anisotropic Temperature and Entropy Distributions Associated with the Large-scale Structure」為標題，於2010年4月9日刊登於天文物理學刊(Astrophysical Journal)的網站上。天文物理學刊是本重量級的天文期刊，2008年的專業影響指數高達6.33，排名全球第四。

參考網站：
http://iopscience.iop.org/0004-637X/



圖片說明：
由星系組成的「大尺度結構」的分布圖 (紫色部份)及星系團內部的溫度分布(粉紅色)。圖中的粉紅色部份越明亮，代表溫度越高 。位於星系團外的纖維狀「大尺度結構」在星系團的左上方，與星系團內部溫度較高的區域相連接。其他只含少數星系的區域(黑色) ，則與星系團內部溫度較低的區域相連接。白線長度代

表一千萬光年(圖片提供：日本理化研究所川原田円博士與中研院天文所岡部信広博士)

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Academica Sinica Press Release

Astrophysicists Capture Growth of Galaxy Clusters, the Largest Cosmic Structures

Galaxy clusters are the largest known gravitationally-bound objects in the Universe. For the first time a team of astrophysicists including Postdoctoral Fellow Dr. Nobuhiro Okabe and Associate Research Fellow Dr. Keiichi Umetsu from the Institute of Astronomy and Astrophysics at Academia Sinica (ASIAA) and Special Postdoctoral Researcher Dr. Madoka Kawaharada from the Institute of Physical and Chemical Research (RIKEN, Japan), have mapped the growth of these cosmic structures. Their research will be published online in "The Astrophysical Journal", a leading astrophysics journal, on April 9, 2010.

Galaxy clusters are composed of a few hundred to a few thousand galaxies, as well as X-ray emitting hot gas and dark-matter. The research team has revealed a snapshot of the dramatic growth of a galaxy cluster named Abell 1689. They discovered that the cluster grows through heating triggered by matter falls from a filamentary large-scale structure outside the cluster known as a "cosmic web".

Using the Suzaku X-ray satellite, the team was able to measure X-ray emission from the hot gas in the outermost regions of Abell 1689. They discovered that the anisotropic temperature distribution of the hot gas is 58 million degrees in one direction and 23 million degrees in the other around the boundary of the cluster. They then compared their X-ray data with a galaxy map made from Sloan Digital Sky Survey (SDSS) data and found that the filamentary large-scale structure of galaxies outside the cluster contacts the hotter realm inside the cluster; in contrast, the other low-density fields, which contain fewer galaxies, contact the cooler gas. The team also compared their X-ray data with gravitational lensing data from the Japanese Subaru telescope and the Hubble Space Telescope, and found that the cooler gas is likely to have sub-sonic motion. Joint analyses of the X-ray, optical and gravitational lensing data have unveiled a clear snapshot of the growth of galaxy clusters being affected by the large-scale structure within which clusters are embedded.

The *Suzaku* satellite is the Japan's fifth X-ray observatory managed by the Japan Aerospace Exploration Agency (JAXA). It was developed by several Japanese

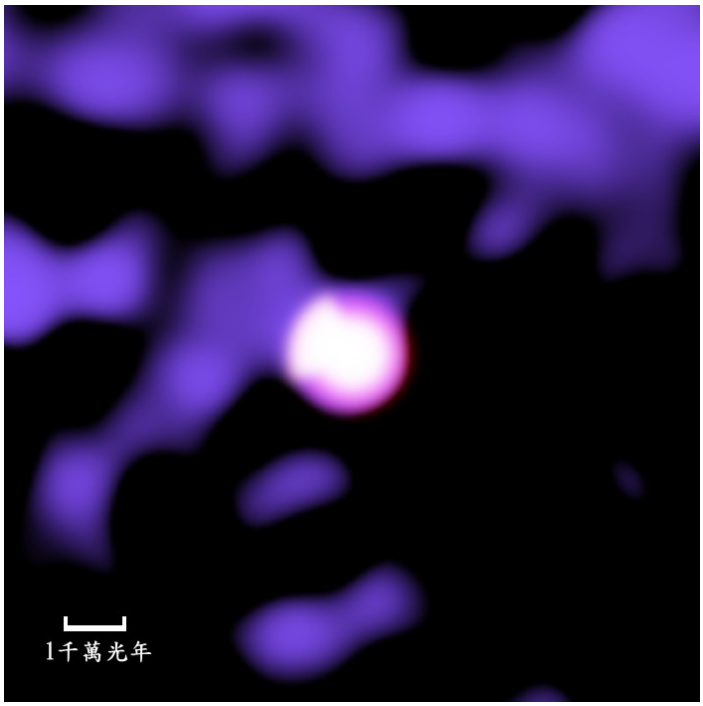
institutions in collaboration with NASA Goddard Space Flight Center (GSFC) in the U.S.

Dr. Nobuhiro Okabe (岡部信広) is a Postdoctoral Fellow at the Institute of Astronomy and Astrophysics (ASIAA). His fields of specialization include galaxy clusters, weak lensing, X-ray and optical analyses and plasma physics. Dr. Keiichi Umetsu (梅津敬一) is an Associate Research Fellow at ASIAA. He has been a science team member of The Yuan-Tseh Lee Array for Microwave Background Anisotropy (AMiBA) project since 2001. His research primarily focuses on the study of galaxy clusters, in particular, weak and strong gravitational lensing.

The other researchers in the project are from a number of Japanese institutions including RIKEN (The Institute of Physical and Chemical Research); Astronomical Institute, Tohoku University; Department of Physics, Yamagata University; Department of Physics, Tokyo University of Science; Department of Physical Science, Hiroshima University; National Astronomical Observatory of Japan; Department of Physics, The University of Tokyo; Department of Physics, Tokyo Metropolitan University.

The research entitled “Suzaku Observation of Abell 1689: Anisotropic Temperature and Entropy Distributions Associated with the Large-scale Structure”, will be published online in “The Astrophysical Journal” on April 9, 2010. In 2008 “The Astrophysical Journal” had an impact factor of 6.33.

Related website:
http://iopscience.iop.org/0004-637X/



Caption:
Maps of the large-scale structure of galaxies (purple) and gas temperature distributions within the cluster (pink). Brighter pink indicates higher temperature. The filamentary structure is found outside the cluster in the top-left direction, in contact with the hotter gas realm. The other fields in which there are few galaxies (black) contact the cooler realm. The white line represents 10 million light-years. (Picture courtesy of Dr. Madoka Kawaharada and Dr. Nobuhiro Okabe)

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