# UK Announces Intention to Join ESO

*(Taken from ESO Press Release 23/00 – 22 November 2000)*


## Summary

On November 22, the Particle Physics and Astronomy Research Council (PPARC), the UK's strategic science investment agency, announced that the government of the United Kingdom is making funds available that provide a baseline for this country to join the European Southern Observatory (ESO).

The ESO Director General, Dr. Catherine Cesarsky, and the ESO Community warmly welcome this move towards fuller integration in European astronomy. "With the UK as a potential member country of ESO, our joint opportunities for front-line research and technology will grow significantly", she said. "This announcement is a clear sign of confidence in ESO's abilities, most recently demonstrated with the construction and operation of the unique Very Large Telescope (VLT) on Paranal. Together we will look forward with confidence towards new, exciting projects in ground-based astronomy."

It was decided earlier this year to place the 4-m UK Visible and Infrared Survey Telescope (VISTA) at Paranal.

Following negotiations between ESO and PPARC, a detailed proposal for the associated UK/ESO Agreement with the various entry modalities will now be presented to the ESO Council for approval. Before this Agreement can enter into force, the ESO Convention and associated protocols must also be ratified by the UK Parliament.


## Research and Key Technologies

According to the PPARC press release, increased funding for science, announced by the UK government today, will enable UK astronomers to prepare for the next generation of telescopes and expand their current telescope portfolio through membership of the European Southern Observatory (ESO).

The uplift to its baseline budget will enable PPARC to enter into final negotiations for UK membership of ESO. This will ensure that UK astronomers, together with their colleagues in the ESO member states, are actively involved in global scale preparations for the next generation of astronomy facilities. Among these are ALMA(Atacama Large Millimeter Array) in Chile and the very large optical/infrared telescopes now undergoing conceptual studies.

ESO membership will give UK astronomers access to the suite of four world-class 8.2-metre VLT Unit Telescopes at the Paranal Observatory, as well as other state-of-the-art facilities at ESO's other observatory at La Silla. Through PPARC the UK already participates in joint collaborative European science programmes such as CERN and the European Space Agency (ESA), which have already proved their value on the world scale. Joining ESO will consolidate this policy, strengthen ESO and enhance the future vigour of European astronomy.

## Statements

Commenting on the funding announcement, Prof. Ian Halliday, PPARC's Chief Executive Officer, said that "this new funding will ensure our physicists and astronomers remain at the forefront of international research – leading in discoveries that push back the frontiers of knowledge – and the UK economy will also benefit through the provision of highly trained people and the resulting advances in IT and commercial spin-offs".

Prof. Mike Edmunds, UCW Cardiff, and Chairman of the UK Astronomy Review Panel which recently set out a programme of opportunities and priorities for the next 10 to 20 years added that "this is excellent news for UK science and lays the foundation for cutting-edge research over the next ten years. British astronomers will be delighted by the Government's rapid and positive response to their case".

Speaking on behalf of the ESO Organisation and the community of more than 2500 astronomers in the ESO member states , the ESO Director General, Dr. Catherine Cesarsky, declared: "When ESO was created in 1962, the UK decided not to join, because of access to other facilities in the Southern Hemisphere. But now ESO has developed into one of the world's main astronomical organisations, with top technology and operating the VLT at Paranal, the largest and most efficient optical/infrared telescope facility in the world. We look forward to receiving our UK colleagues in our midst and work together on the realization of future cutting-edge projects."

Joining ESO was considered a top priority for UK astronomy following a community report to the UK Long Term Science Review, which set out a programme of opportunities and priorities for PPARC science over the next 10 to 20 years. The report is available on the web at URL: www.pparc.ac.uk/ltsr.

# The VLT Weighs the Invisible Matter in the Universe

## SHAPES AND ORIENTATIONS OF 76,000 DISTANT GALAXIES

*(Taken from ESO Press Release 24/00 – 1 December 2000)*


## Summary

An international team of astronomers[1] has succeeded in mapping the "dark" (invisible) matter in the Universe, as seen in 50 different directions from the Earth. They find that, within the uncertainty, it is unlikely that mass alone would stop the current expansion of the Universe.

This fundamental result is based on the powerful, but challenging method of "cosmic shear". It depends on very accurate measurements of the apparent, weak distortion and preferential orientation of images of distant galaxies. This effect is caused by deflection of the light from those galaxies by the


[1] The team consists of Yannick Mellier (Principal Investigator [PI], Institut d'Astrophysique de Paris [IAP] and Observatoire de Paris/DEMIRM [OP-DEMIRM], France); Ludovic van Waerbeke (co-PI, IAP); Roberto Maoli (IAP, OP-DEMIRM and University La Sapienza, Rome, Italy); Peter Schneider (University of Bonn, Germany); Bhuvnesh Jain (John Hopkins University, Baltimore, USA); Francis Bernardeau (Service de Physique Theorique, C.E. de Saclay, France); Thomas Erben (Max-Planck-Institut für Astrophysik, Garching, Germany, IAPand OP-DEMIRM), and Bernard Fort (IAP).

large mass concentrations in the Universe it encounters on its way to us. The larger these masses are, the larger are the apparent image distortions and the more pronounced are the alignments of neighbouring galaxy images.

The new analysis was made possible by means of unique observational data, obtained under excellent conditions with the the ESO 8.2-m VLT ANTU telescope and the multi-mode FORS1 instrument at the Paranal Observatory.

## The VLT Observations

An international team led by astronomers at the Institut d'Astrophysique de Paris used for the first time the VLT to probe the mass density of dark matter in the Universe, by means of weak gravitational lensing effects. The team selected 50 different sky fields which were then observed in service mode by the ESO staff at the Paranal Observatory.

Long exposures of these fields were made with the FORS1 instrument (in its imaging mode) on the VLT 8.2-m ANTU telescope and only during nights with the very best observing conditions. In fact, 90% of the fields have image quality better than 0.65 arcsec, guaranteeing a superb basis for the subsequent study.

## Clumps of Dark Matter

The unprecedented quality of these data enabled the astronomers to measure the shapes and orientations of the images of more than 70,000 galaxies with very high precision. After a careful statistical analysis, they were able to demonstrate that the distant galaxies are not randomly oriented on the sky – they show a a certain degree of alignment over substantial sky areas (to distances of several arcmin). The astronomers refer to this as a coherent orientation. It can only be explained by gravitational lensing effects produced by clumps of dark matter in space, distributed along huge "filaments". Figure 1 demonstrates this, by means of the VLT exposure (left) and the deduced mass distribution in the same direction, based on these measurements (right).

## The Weak Lensing Effect

The gravitational lensing effect was predicted by Einstein's theory of general relativity at the beginning of the 20th century. When the light of a distant galaxy passes close to a concentration of matter in space, it will be (more or less) deflected, due to the effect of the field of gravity of this matter. The observed image of the galaxy is therefore distorted. Very strong gravitational lensing effects (by very heavy objects) produce spectacular gravitational arcs observed in some rare clusters of galaxies, cf. the VLT images of CL2244-0 (http://www.eso.org/outreach/press-rel/pr-1998/phot-46d-98-preview.jpg) and Abell 370 (http://www.eso.org/outreach/press-rel/pr-1998/phot-47c-98-preview.jpg).

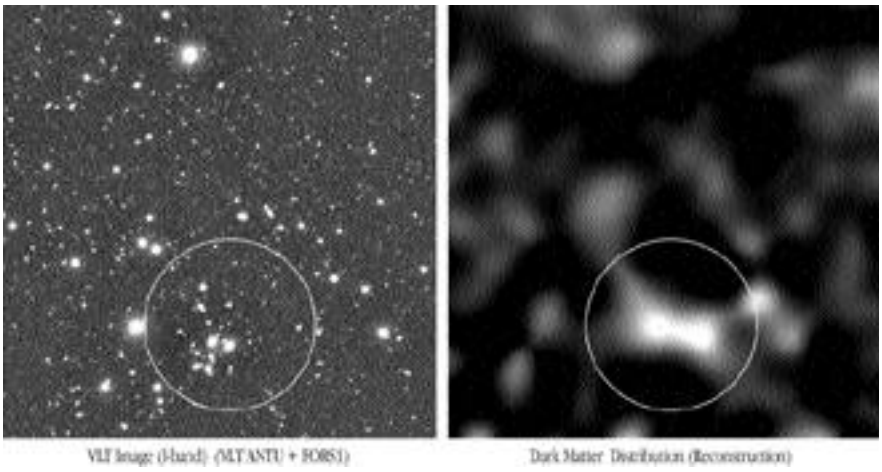


*Figure 1: The figure shows an example of the mapping of the dark mass distribution in one of the 50 sky fields observed with the VLT and FORS1. To the left is the original image, a 36-min exposure in a near-infrared wavelength band. To the right is the reconstructed map of the mass (a "mass photo") in this direction, based on an analysis of the weak shear effect seen in the field; that is, on the measured elongations and directions of the axes of the galaxy images in this field. The brighter areas indicate the directions in which there is most mass along the line of sight. The circle in the left photo surrounds the images of a distant cluster (or group) of galaxies, seen in this direction. Note that there is a corresponding concentration of mass in the "mass photo"; this is obviously the mass of that cluster. The mass reconstruction map shows the (mostly) dark matter responsible for the cosmic shear found on the small scales, now measured with the VLT.*

Much weaker lensing effects (by less massive objects) are in fact present everywhere in the Universe, but they are not easy to detect. This was the effect the astronomers searched for. It manifests itself as a small stretching in a particular direction of the images of all galaxies that are located behind the gravitational lens. This phenomenon may then be observed as an alignment of galaxies in that particular sky area. The existence of the lens and its overall mass and extension can then be determined, albeit with some uncertainty only.

## An Important Contribution to the Map of the Universe

Thanks to the large light collecting power of the VLT and the superb quality of the present images, the team succeeded in detecting large-scale, weak lensing effects in the Universe, in a large number of different (and thus independent) directions. Moreover, the analysis of this large data sample enabled the astronomers, for the first time, to set limits to the overall mass density of the universe, by means of the gravitational lensing by large-scale structures. It turns out that their results are in remarkable agreement with the current constraints obtained by other cosmological considerations.

This kind of investigation is rather difficult and cannot be based on individual sky fields alone. The final result, in terms of the inferred mass density of the Universe, only emerges when "adding" all of the 50 observed fields. Making the reasonable assumption that the distribution of galaxies and dark matter in space is similar, the new investigation shows that the total matter density is less than half of what is needed to stop the current cosmic expansion. The new result also supports the existence of a non-zero "cosmological constant" (vacuum energy), already indicated by supernova observations.

In the ongoing quest for establishing the first true mass map of the Universe from the gravitational lensing effects caused by this mass, the VLT has now demonstrated its great potential with bravura. The light collecting power and, not least, its excellent image quality provides what is likely to be the best observing configuration for this very challenging research programme. It was also made possible because of the opportunity to use the VLT Service Mode during which ESO staff astronomers at Paranal are responsible for carrying out the actual observations, at the moment of the very best atmospheric conditions.

## More Information

The research described in this Press Release is reported in a research article ("Cosmic Shear Analysis in 50 Uncorrelated VLT Fields. Implications for Omega-0 and sigma-8."), submitted by the team to the European journal "Astronomy and Astrophysics". Note also the related article in the *The Messenger* No. 101, p. 10–14, September 2000).