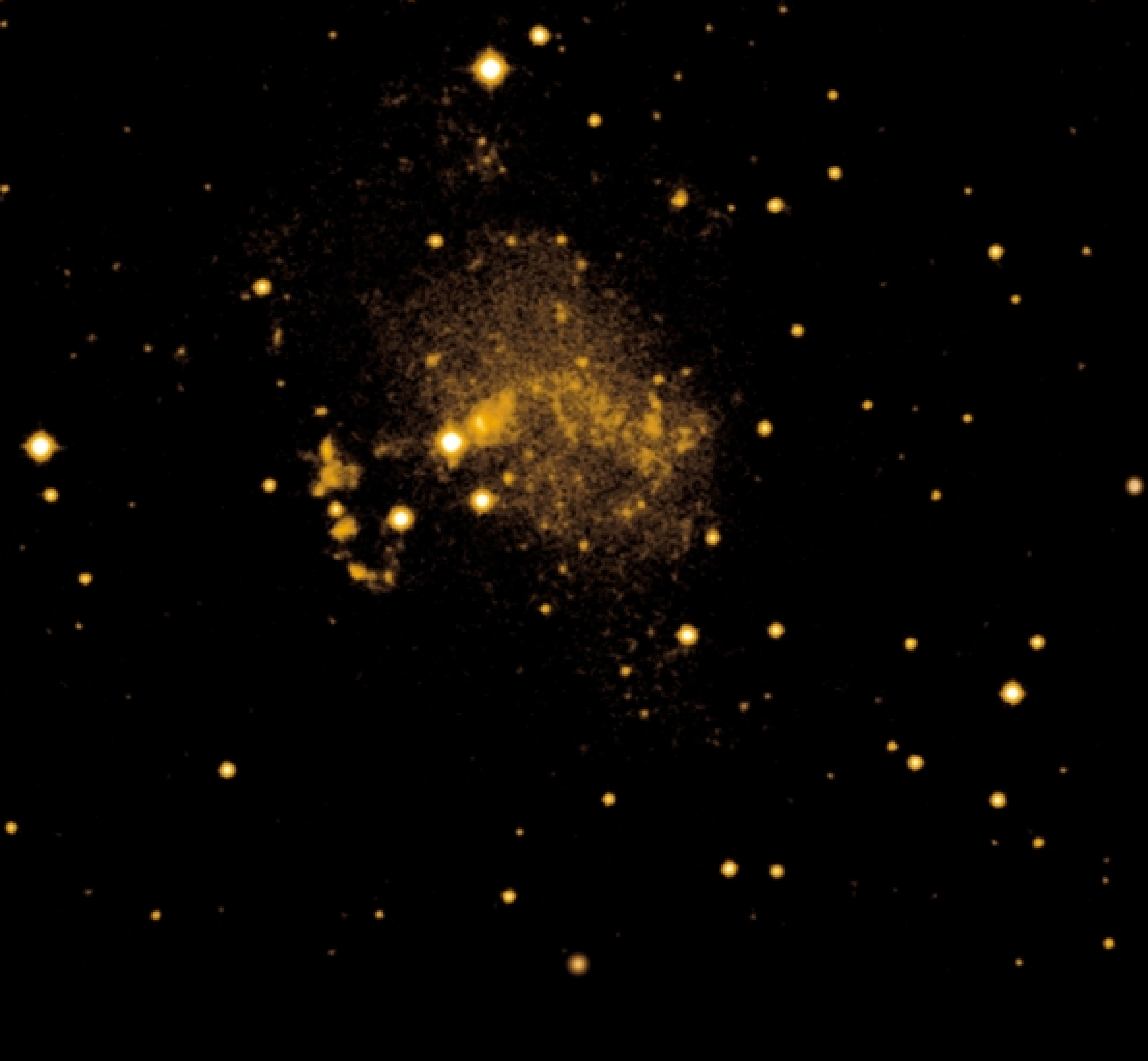
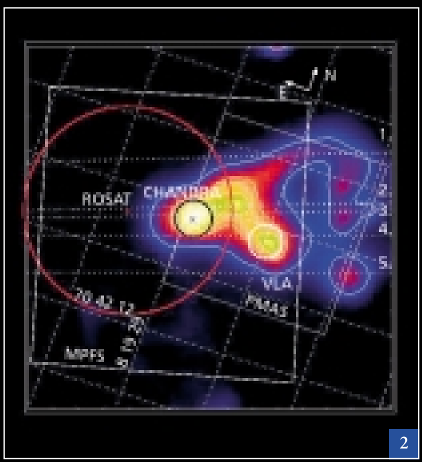


Black Hole in the Holmberg II Galaxy

Fig. 1 (large figure):
The Holmberg II dwarf galaxy (Palomar image)

Fig. 2:
Positional charts of the x-ray recordings of Ho II-X1 as an overlay over an image of the visual spectral range (false-color image). The high excitation nebula surrounding the black hole proven to exist by PMAS is indicated by a black circle.

Galaxies are clusters of stellar systems outside the Milky Way that occur in two main forms. Elliptic galaxies have a homogeneous, triaxial structure and a uniform stellar population. Spiral galaxies have a spiral structure and differential rotation, the spiral arms being the centers of star formation. Our closest neighbor, the Andromeda Nebula (M 31, NGC 224), is a spiral galaxy of type Sb in the Andromeda constellation. Galaxies are separated from each other by immense, largely empty space. At a rough estimate, more than 50 billion galaxies can theoretically be observed from the earth using state-of-the-art technology. It is estimated that an average galaxy consists of some 100 billion stars.



The brightest object in the class of ultra-luminous x-ray sources (ULX) in the local group, i.e. the cluster of galaxies closest to the Milky Way, is situated in the Holmberg II dwarf galaxy approx. 10 million light-years away (Fig. 1). In addition to investigations in the x-ray range, the search for emissions in the visual range of the spectrum is of key interest. It is hoped that spectral analysis of this radiation may allow scientists to make a conclusion regarding the nature of accretion and the mass of the object.

During the PMAS Science Verification Run at the Calar Alto 3.5 m telescope, Ho II-X1 was observed which indeed demonstrated the extremely faint signature of a high-excitation gas nebula at the site of the x-ray source (Fig. 2). Earlier observations with an elongated slit spectrograph had been unsuccessful as the uncertain positional information from the x-ray data made a "coincidental" hit in directing the telescope very unlikely. The 8x8 arc second field of view of the PMAS made it possible to direct the telescope without having to make presumptions regarding the suspected coordinates so that the high excitation helium II emission line at 486.6 nm, as an indicator, appeared just on the edge of the field of view. The analysis of the dimensions of the object and its kinematic properties together with the x-ray observation data indeed showed that Ho II-X1 is highly likely to be an intermediate-size black hole. The results obtained by the international research group of Lehmann (Max Planck Institute of Extraterrestrial Physics, Garching, Germany) and the PMAS team (AIP) were published as the cover story in the March 2005 issue of the renowned technical journal, Astronomy & Astrophysics.

Fig. 3a: Top: Monochromatic images at various important wavelengths extracted from the data cube of a PMAS recording. Bottom: Velocity field (false-color chart) and width at half intensity of the emission lines of hydrogen at 486.1 nm (H-beta) and oxygen at 500.7 nm ([O III]). A red circle at the lower left marks the point at which the high excitation helium emission line was detected.

Fig. 3b: The spectrum generated by addition within the red circle (Fig. 3a). The weak emission line indicated by He II (singly-ionized helium) shows that a compact, extremely hot source resides in this area. The same line is not detectable in other regions.

Fig. 3c: Actual observation of a gravitational lens, in which a low-luminosity galaxy in the foreground (faint red spot in the center), rather than a black hole, splits the light of a far-away bright quasar behind the galaxy in the foreground into 4 components (PMAS observation). Quasars are enormously bright, active galaxy cores, in which accretion towards a super mass-rich black hole gives rise to luminosity exceeding the total brightness of the galaxy by far.

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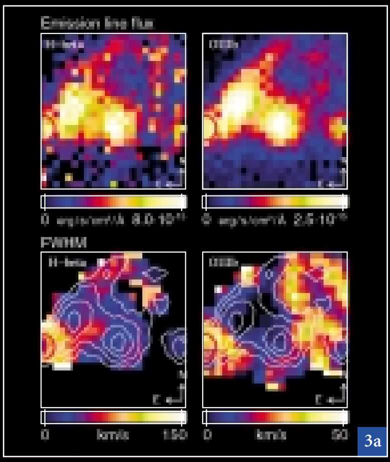

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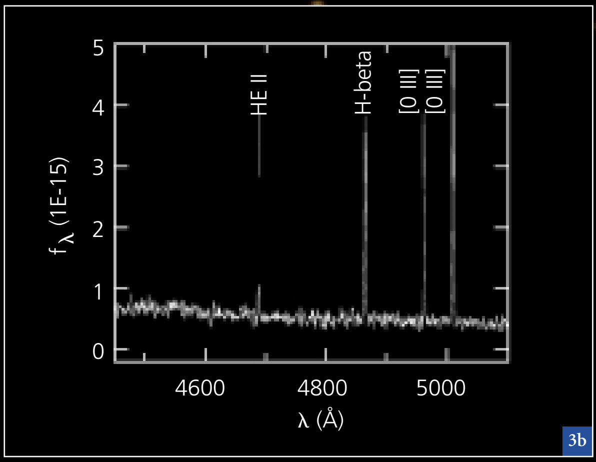

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