The most distant massive object ever detected

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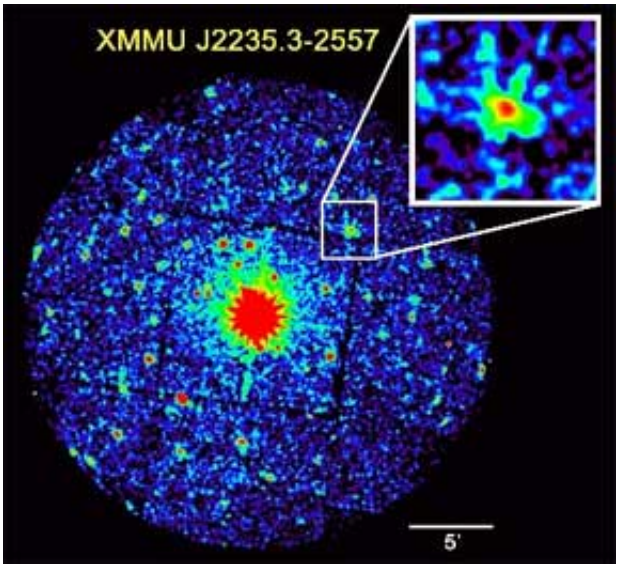

An international team of astronomers using the world's largest X-ray and optical telescopes have spotted the most distant massive object ever detected, a cluster of galaxies 9 billion light years distant from Earth. The cluster of galaxies is so far away that the light detected by the team is much older than the Earth itself. The galaxy cluster, if it is even still there, would be at least 11 billion years old now. "By capturing this ancient, 9-billion-year-old light, we have a snapshot of the universe at a youthful age of less than 5 billion years, which is about 1/3 of the present age," said project leader Christopher Mullis, a research fellow in the University of Michigan's Department of Astronomy.

As exciting as it is to break a record, it's also an important cosmological finding. "Just a few years ago, astronomers did not believe structures like this even existed at such an early time," Mullis said. This galaxy cluster, which is being seen as it appeared about 2 billion years after its formation, is well-organized and "mature," he said. Although it is very far back in time, it looks as if this structure had formed in a way that is consistent with more recent structures.

"Even at this early stage in cosmic history, this appears already as a mature, fully assembled structure which implies that this is an old cluster in a young universe," said European Southern Observatory astronomer Piero Rosati, who collaborated on the study.

The record-breaking galaxy cluster was also a somewhat surprising find for the team, who were testing a new approach to hunting distant objects. "Basically we stepped up to the plate for our first time at bat with this new system, and we hit a home run," Mullis said.

Mullis and his colleagues started their search by combing through archives of old images from the European Space Agency's orbiting X-ray observatory, XMM-Newton, looking for diffuse X-ray sources that had not been previously studied. Cluster galaxies shine brightly in optical light, but they also emit strong X-ray signals resulting from very hot gas that envelopes the cluster.

The record-breaking cluster initially turned up, small but distinct, off center in an image made by another team.

The X-ray image of the distant cluster is comprised of just 280 photons---individual parcels of light---collected over a 12.5-hour exposure. By comparison, on a sunny day the human eye is flooded by about 10 quadrillion photons per second.

With this distant cluster candidate and dozens of others culled from the X-ray archive, Mullis and his team then turned to one of the world's largest optical telescopes, the European Southern Observatory's Very Large Telescope, located in the Atacama Desert, Chile. They took a series of relatively quick exposures of the candidates with red and blue filters on the telescope.

What Mullis and his Italian and German collaborators were looking for at each of the candidate spots were very red galaxies, indicating light that has traveled for an extremely long time to reach Earth. "The redder the better," Mullis said. Almost immediately, they turned up this cluster of red objects that seemed to be beyond the previous distance record.

"I spent a full day rechecking my data before I called any of the other scientists," Mullis said. "It appeared to be almost unbelievably distant."

Subsequent, more detailed measurements on 12 major galaxies in the cluster were used to confirm that they were equidistant from Earth at about 9 billion light years. The entire cluster is probably hundreds or even thousands of galaxies held together by gravity, Mullis said.

Collaborator Hans Bohringer of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany said the discovery "encourages us to search for additional distant clusters using the same efficient techniques used to locate the present cluster."

Mullis and his team are going to broaden the search to find more super-distant galaxy clusters with this new approach. They also plan to go back and take longer optical and X-ray telescope exposures of the record-setting cluster to get a better sense of its features.

"Finding it is one thing," Mullis said. "We also need to go back in there and maximize that return." With enough data on this and other super-

distant massive objects, Mullis expects to find new answers to some fundamental questions of how the universe formed.

Mullis will be presenting this finding at an international astronomy conference in Hawaii focused on connecting galaxy clusters to the underlying physics of space time and gravity. The meeting is being organized by U-M physics professor Gus Evrard, and sponsored in part by the Michigan Center for Theoretical Physics.

"It's special to live in the era of human history when the terrain of the whole visible universe is being revealed," Evrard said.

A paper by Mullis and his team will also appear in an upcoming issue of The Astrophysical Journal.