Did 'Dark Gulping' Generate Black Holes in Early Universe?

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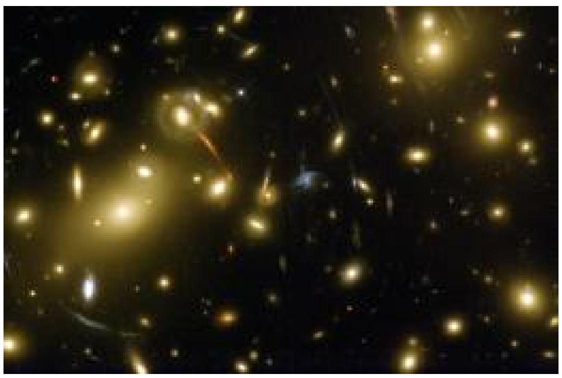

The HST WFPC2 image of gravitational lensing in the galaxy cluster Abell 2218, indicating the presence of large amount of dark matter (credit Andrew Fruchter at STScI).

(PhysOrg.com) -- A process called 'dark gulping' may solve the mystery of the how supermassive black holes were able to form when the Universe was less than a billion years old.

Dr Curtis Saxton will be presenting the study at the European Week of Astronomy and Space Science at the University of Hertfordshire in Hatfield.

Dr Saxton and Professor Kinwah Wu, both of UCL's Mullard Space Science Laboratory, developed a model to study the gravitational interactions between the invisible halo of dark matter in a cluster of galaxies and the gas embedded in the dark matter halo. They found that the interactions cause the dark matter to form a compact central mass, which can be gravitationally unstable, depending on the thermal properties of the dark matter. If the cluster is disturbed, the dark matter central mass would undergo a very rapid collapse, without a trace of electro-magnetic radiation being emitted. This fast dynamical collapse of the unstable dark-matter is called dark gulping.

The affected dark mass in the compact core is compatible with the scale of supermassive black holes in galaxies today. There are several theories for how supermassive black holes form: one possibility is that a single large gas cloud collapses, another is that a black hole formed by the collapse of a giant star swallows up enormous amounts of matter; another possibility is that a cluster of small black holes merge together. However, all these options take many millions of years and are at odds with recent observations that suggest that black holes were present when the Universe was less than a billion years old. Dark gulping may provide a solution to how the slowness of gas accretion was circumvented, enabling the rapid emergence of giant black holes.

"Dark matter appears to gravitationally dominate the dynamics of galaxies and galaxy clusters. However, there is still a great deal of conjecture about origin, properties and distribution of dark particles. We can only be certain that dark matter is non-interactive with light, but it interacts with ordinary matter via gravity. Previous studies have ignored the interaction between gas and the dark matter but, by factoring it into our model, we've achieved a much more realistic picture that fits better with observations and may also have gained some insight into the presence of early supermassive black holes," said Dr Saxton.

According to the model, the development of a compact mass at the core is inevitable. Cooling by the gas causes it to flow gently in towards the centre. The gas can be up to 10 million degrees at the outskirts of the halos, which are few million light years in diameter, with a cooler zone towards the core, which surrounds a warmer interior a few thousand light years across. The gas doesn't cool indefinitely, but reaches a minimum temperature, which fits well with X-ray observations of galaxy clusters.

The model also investigates how many dimensions the dark particles move in, as these determine the rate at which the dark halo expands and absorbs and emits heat, and ultimately affect the distribution of dark mass the system.

“In the context of our model, the observed core sizes of galaxy cluster halos and the observed range of giant black hole masses imply that dark matter particles have between seven and ten degrees of freedom,” said Dr Saxton. “With more than six, the inner region of the dark matter approaches the threshold of gravitational instability, opening up the possibility of dark gulping taking place.”

The findings have been published in the *Monthly Notices of the Royal Astronomical Society*.

More information: “Radial structure, inflow and central mass of stationary radiative galaxy clusters”, Curtis Saxton & Kinwah Wu, *Monthly Notices of the Royal Astronomical Society*, Volume 391 Issue 3, Pages 1403 - 1436.

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