

# Universe's first stars may have been dark

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Maggie McKee

The universe's first stars may have been bloated behemoths powered by dark matter, suggests an intriguing, if speculative, new study. These 'dark stars' might have delayed the creation of heavy elements, which make up everything from planets to people, as well as cosmic reionisation, which made the universe transparent to light billions of years ago.

Theorists believe the first stars formed in cradles of dark matter, condensing from clouds of gas until their cores became so dense that nuclear fusion ignited.

But previous research did not consider how the dark matter cradles themselves might affect star formation, say Douglas Spolyar of the University of California in Santa Cruz, Katherine Freese of the University of Michigan in Ann Arbor, and Paolo Gondolo of the University of Utah in Salt Lake City, all in the US.

When they accounted for dark matter, they discovered it could have had a profound influence on the first stars.

Just what that effect is is still unclear, since no one knows what dark matter is – astronomers merely detect its gravitational pull on normal matter. But if it is made of weakly interacting massive particles, or WIMPs, as many scientists believe, Spolyar and his colleagues say it could alter our understanding of the early universe.

They used a candidate WIMP called a neutralino in their calculations and found that as a primordial gas cloud contracted, it reached a threshold density in which the dark matter particles swaddling it began to interact with each other. They annihilated on contact, producing particles such as electrons as well as photons of light that then deposited energy into the cloud.

**Infrared glow**

This could heat up the cloud so much that it would stop contracting, so that it was supported by the annihilation of dark matter rather than by nuclear fusion, like normal stars. Such a 'dark star' would be about as massive as the Sun and would glow at infrared wavelengths. But it would be much larger – depending on the mass of the neutralino used, the star could span anywhere from the distance between the Sun and Uranus in our solar system to nearly 60 times that size.

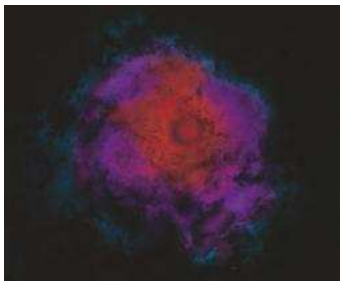
"To call it a dark star is a bit of a misnomer – it simply has a different source of internal energy to support the star against gravity," says Volker Bromm of the University of Texas in Austin, US, an expert on the universe's first stars who is not a member of the study. "It would be a ball of gas that would have a reddish glow."

Could any of these stars still survive today? Possibly, depending on the neutralino mass, say the researchers. "They could be flying around our galaxy," Spolyar told **New Scientist**. In that case, the very first generation of stars in the universe – so-called 'population III' stars – would have been "very different beasts" than previously thought, the team says.

Nearly all of the elements in the universe aside from hydrogen and helium were forged inside stars, and "the first stars are the first step in that process", team member Freese told **New Scientist**. If the first stars were dark, "there could be a major delay or even a stopping of this process", she says.

**Primordial cloud**

"It may turn out that the early star formation and



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Dark matter could prevent clouds of hydrogen and helium from contracting into normal stars in the early universe, according to a new study. But even though the clouds would not ignite nuclear fusion to shine like our Sun, they would be heated by the annihilation of dark matter, glowing at infrared wavelengths (Illustration: University of Utah)

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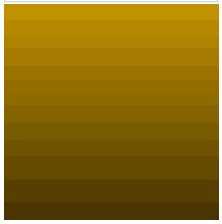

Sex and Cloning

consequently the synthesis of elements went differently than we thought," comments Igor Moskalenko of Stanford University in California, US. "If so, we have evidence of the dark matter presence literally in every cell of our body."

Other 'pop III' stars – which formed inside early galaxies rather than isolated dark matter cradles – would thus have been responsible for seeding the universe with its first heavy elements.

That suggests that heavy elements may not be spread evenly throughout space, since the stars in early galaxies would have enriched their surroundings in these elements and left voids of relatively empty space unenriched, says Bromm. If astronomers ever find a truly primordial cloud of gas in the universe, then it might hint that the first stars were dark.

Similarly, the first stars are thought to have helped ionise the universe within a few hundred million years after the big bang, making it transparent to ultraviolet light. (This phenomenon is actually referred to as 'reionisation', since the universe was a scalding soup of charged particles immediately after the big bang. It then cooled down enough for ions to coalesce into neutral atoms after 370,000 years or so.)

**Micro and macro**

If the first stars were dark, then that suggests the stars in early dwarf galaxies would have been responsible for reionising the universe, says Bromm.

"Another thing that's exciting to me is that we may have a new type of star and we can go look for these things," says Freese. Neutrinos produced by the annihilation of dark matter in the stars might turn up in detectors such as AMANDA and IceCube at the South Pole, and gamma-ray photons produced in the same process could be picked up by NASA's GLAST spacecraft, due to launch in mid-2008.

Bromm says the research is quite speculative, since there are "incredibly many degrees of freedom when it comes to the properties of dark matter". But he adds that the work helps to bridge the gap between studies of dark matter on a particle physics scale and its effect on astronomical objects. "This paper is one of the first in this very interesting line of convergence between micro and macro physics," he told **New Scientist**.

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Journal reference: *Physical Review Letters* (forthcoming)

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