First stars might have been powered by dark matter

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For a long time, scientists have assumed that the very first stars were powered by fusion, in processes similar to what goes on in present day stars. But a new theory is emerging to challenge that view. "The first stars were different in a lot of ways," Katherine Freese, a theoretical physicist at the University of Michigan, tells *PhysOrg.com*.

Freese, along with Douglas Spolyar at the Unversity of California, Santa Cruz and Paolo Gondolo at the University of Utah in Salt Lake City, posit that dark matter annihilation was the source of energy that powered the earliest stars, formed about the time the universe was between 100 and 200 million years old.

If they are right, some of what we know about stellar formation – and the formation of the universe itself – could be called into question. Their work appears in *Physical Review Letters* with the title "Dark Matter and the First Stars: A New Phase of Stellar Evolution."

"Annihilation means that matter goes into something else," Freese explains. She says that everything has a partner opposite – matter and anti-matter, electrons and positrons. When these opposites meet, their identity is lost and the energy goes elsewhere. "Dark matter particles are their own anti. When they meet, one-third of the energy goes into neutrinos, which escape, one-third goes into photons and the last third goes into electrons and positrons."

"In order for a star to form, in order for its matter to collapse into a dense object, it has to be able to cool off," Freese continues. "We noticed that in the first stars something was competing with the cooling. The stars couldn't collapse down small enough to get fusion going. But they were still giving off energy. They were in a phase we hadn't discovered before."

Freese describes how the first stars likely moved from the dark matter phase and into the fusion phase. "The annihilation products getting stuck is what allows the dark matter heating to stay inside the star, and is what prevents the star from collapsing into a fusion driven one."

When all the dark matter is gone, Freese says, the star can collapse enough for fusion to take over inside the star. Hydrogen and helium atoms are forced together by this process to form new elements (carbon, nitrogen, oxygen and metals) until it becomes dense enough to collapse in on itself. Finally, the star goes supernova, spewing the new elements created in its core across the universe to be used in the formation of later stars.

"This new phase is only true in the first stars," Freese insists. "The stars we see today are called population one stars. Earlier stars were population two stars. The first stars are referred to as population three stars. Our work is to modify how we believe population three stars developed. At first, they weren't fusion driven."

If Freese and her colleagues are right, it could change what we know about how stars are formed. "It adds a new phase of stellar evolution," Freese says. She says that studying this theory will have to wait until 2013, when NASA is scheduled to launch the James Webb Telescope. "We call them dark stars," Freese explains, "but they would still shine, looking a little different. They would be cooler than a fusion driven star. We hope the next phase telescope will be able to tell between the standard stars now, and what we think happened in the first stars."

Until then, Freese and her peers will continue to speculate on the properties of the first stars, and try to figure out how the new phase in stellar evolution might have affected the timing of other developments in the universe. “It really gets into speculation here,” she says, “but this could affect the timing of the fist black holes, and the development of our own galaxy.”