For both big matter mysteries, the answer may be 'antimatter'

Scientists have been groping in the dark to find dark matter for so long that science writers have run out of dark-side-of-the-universe jokes.

But scientists have not run out of ideas for what the dark matter might be. A new paper suggests the intriguing possibility that most of the universe's mass is not some exotic subatomic particle, but — get this — antimatter!

It's not your ordinary everyday antimatter. Rather it's nuclear particles, made of quarks (well, antiquarks) in the form of superdense globs known as quark nuggets. As a bonus, this new idea also explains why there seems to be mostly matter in the universe and very little antimatter.

For decades, astronomers have known that some invisible form of matter influences how fast galaxies spin and how they clump together in clusters. Various measurements show the invisible (or "dark") matter to be five times as abundant as the visible atomic matter of stars and other ordinary things like planets and people. A consensus has emerged that the dark matter must be composed of vast numbers of a new species of subatomic particle permeating the cosmos. These particles would not interact with light (hence their invisibility) or ordinary matter except through gravity and the weak nuclear force. Bottom line: such particles are very difficult to detect, but very sensitive experiments in deep underground laboratories have been trying.

Some of these have claimed dark matter detections, or at least hints, but others see nothing. Perhaps the failure of these experiments to find definitive signs of dark matter may be because it is not made of the kind of particles that everybody is looking for, say Kyle Lawson and Ariel Zhitnitsky of the physics and astronomy department at the University of British Columbia. Their nuggets would not de detectable by current experiments. At the same time, they say, their idea would solve a second longstanding cosmic mystery: why the universe apparently contains so little antimatter.

In the beginning, the universe should have contained equal amounts of matter and antimatter, or so the basic laws of physics would lead you to believe. Of course, then all the matter would have annihilated all the antimatter (or vice versa), leaving nothing. Since there obviously is a lot of matter around, some tweaks in the basic laws must have been at work to tip the primordial scale in matter's favor.

Lawson and Zhitnitsky say the same process could explain both the antimatter and dark matter problems.

"Two of the largest open questions in cosmology, the origin of the matter/antimatter asymmetry and the nature of the dark matter, may have their origin within a single theoretical framework," Lawson and Zhitnitsky write in a new paper (arxiv.org/abs/1305.6318).

It all happened about a microsecond after the birth of the universe. Until then, all matter swirled about in a hot soup known as the quark-gluon plasma, cooked up by the heat of the big bang explosion. But by a microsecond after the bang began, the universe had cooled enough for the quarks to congeal into the ordinary particles of matter still around today, such as protons and neutrons.

But suppose (as experts in the past have postulated) that not all the quarks formed ordinary particles. Some might have coagulated into huge (by subatomic standards) globules perhaps a thousand times the width of an atom. Such nuggets would be as dense as an atomic nucleus but perhaps millions of times bigger.

And don't forget, the original quark soup contained antiquarks as well as quarks. Antiquarks would have had an even higher likelihood of coagulating into nuggets instead of antiprotons or antineutrinos. Lawson and Zhitnitsky suggest that in a plausible scenario ordinary quarks would be twice as likely to form nuggets in preference to ordinary atomic matter; antiquarks would be three times as likely. In other words there would be twice as much mass in matter nuggets as in ordinary atomic particles, and three times as much mass in antinuggets. That gives a 5-to-1 ratio of nuggets (plus antinuggets) to ordinary matter in the cosmos, just the ratio of dark matter to visible matter that astronomers deduce from their observations today.

So the dark matter mystery is explained because most mass is trapped in nuggets, and the antimatter mystery is explained because most of the mass trapped in nuggets is antimatter.

Fortunately, the nuggets are not entirely unobservable. They're just not what scientists have been looking for. They would be much scarcer than the particles (known as WIMPs) that underground labs try to detect. Nugget detectors would have to be spread out over wide areas, like the detectors seeking to capture signs of high-energy cosmic rays. Perhaps those detectors could be tweaked to find signs of antinuggets penetrating the atmosphere, where they would annihilate atoms in the air, producing possibly detectable debris. (Nuggets are so dense that they would then usually just zip right through the Earth.)

Lawson and Zhitnitsky say their antinuggets could also explain various signals from space that have been taken as signs of dark matter annihilation. And experiments in Antarctica might also be able to detect signs of nuggets moving through the ice.

Not everybody will like this idea, though. Somebody is probably working on a paper right now detailing why the antinugget proposal won't work. But before other physicists conclude that this antimatter/dark matter proposal is wrong, they might first want to figure out what's right. And that's what they haven't been able to do.

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