Out There

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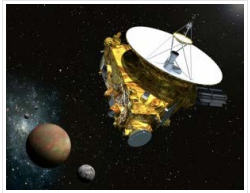
Ask Discover: Does Dark Matter Affect the Navigation of a Spacecraft?

By Corey S. Powell | July 29, 2013 2:15 pm

This question came up as part of a new Q&A column running monthly in DISCOVER magazine. I love responding to reader queries; answering them in a meaningful way almost always leads to some interesting new ideas. (Got a burning science question of your own? Send it to Ask@DiscoverMagazine.com and we'll try to answer it here or in a future issue of the magazine.)



The New Horizons spacecraft will fly past Pluto and its large moon, Charon, on July 14, 2015. Planning such an exact encounter is possible because there are no major dark effects at play within the solar system. (Credit: JHUAPL/SwRI)

On to the answer part. You might think that dark matter would be a significant factor when NASA plots the kind of trajectories that sent Cassini to Saturn, or the New Horizons spacecraft on its way to a 2015 rendezvous with Pluto. After all, dark matter seems to greatly outweigh the visible kind. But as with so many things in astronomy, human intuition turns out to be a poor guide. In reality, the effect of dark matter on a spacecraft within the solar system is basically zero — much smaller than the subtle effects of sunlight and solar wind, not to mention outgassing from equipment and heat radiated from the spacecraft itself.

The reason why dark matter has so little impact is that it is extremely diffuse. The inferred density of dark matter, based on the motions of nearby stars, is equivalent to about five hydrogen atoms per cubic inch. Over vast cosmic scales, that adds up to a lot of material–nearly six times as much as all of the visible matter in the universe, based on the latest data from the Planck mission.

On the local scale, however, the dark density does not add up to much. Within the boundaries of the classical solar system (defined by the orbit of Neptune), that comes to only about one trillionth the mass of the sun. Furthermore, that material is probably spread out evenly, so it's not even pulling a spacecraft all in one direction.

The deeper question is why dark matter is so diffuse, while visible matter clumps together conveniently into dense things like stars and planets. Nobody has detected dark matter directly, so there is no definitive answer to that question. Right now, all scientists can do is plot where the dark matter appears to be, based on its gravitational effects, which is how they know it is spread out extremely thinly.

The simplest explanation is that dark matter–whatever it is–must not have any way to cool off and collapse the way ordinary matter does. Recently, some theorists have begun to question that assumption, however. It is clear that at least *some* dark matter must be diffuse, based on how it affects the motions within galaxy clusters and how it distorts the light from more distant galaxies. But maybe not all of it is. Lisa Randall of Harvard University and others have pointed out that dark matter might contain a second component that could form structure just the way visible matter does.

If so, our galaxy could contain dark structures within it it. There could be a dark disk that mirrors the disk of the Milky Way. Possibly there could even be dark stars and dark planets. Right now scientists do not know enough to test the idea, though they are getting close (see my recent column on this topic). A good test would be to watch the motions of stars in the Milky Way at very high precision, something that the upcoming Gaia probe will do.

One thing we can be quite sure of is that there are no dark planets or dark stars lurking right here in our solar system, because it would affect the motions of the planets and spacecraft in easily observable ways. Astronomers would love to study dark matter by measuring its pull on a space probe, but the actual effect is so small that nobody has figured out how to do that yet.

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- **Roger**

  Don't we get ahead of ourselves by talking about dark matter as if it really exists? Isn't it true that all we really have are observations of galactic rotations that we can't explain? Dark matter is postulated as a possible explanation but has never actually been detected or proven to exist. It is simply the most palatable explanation because any other explanation implies that our understanding of how the universe works has some serious gaps.

- **coreyspowell**

  You are quite right that the existence of dark matter is still a matter of inference; that is why there are multiple dark-matter searches now underway, both on Earth and in space. But the circumstantial evidence for dark matter is considerable, as I noted in an earlier post:

  http://blogs.discovermagazine....

- **eetom**

  In other words, we are still in the dark about dark matter. That makes sense. Otherwise, dark matter is no more "dark" is it?

- **Tim Burns**

  Dark matter is the subject of my new science-fiction novel, "Ghosts of the Void". In this book I postulate that dark matter can have quite observable effects on spacecraft and even us. Check it out on http://www.amazon.com/Ghosts-V...