Sean Carroll

in truth, only atoms and the void

More Messy Dark Matter

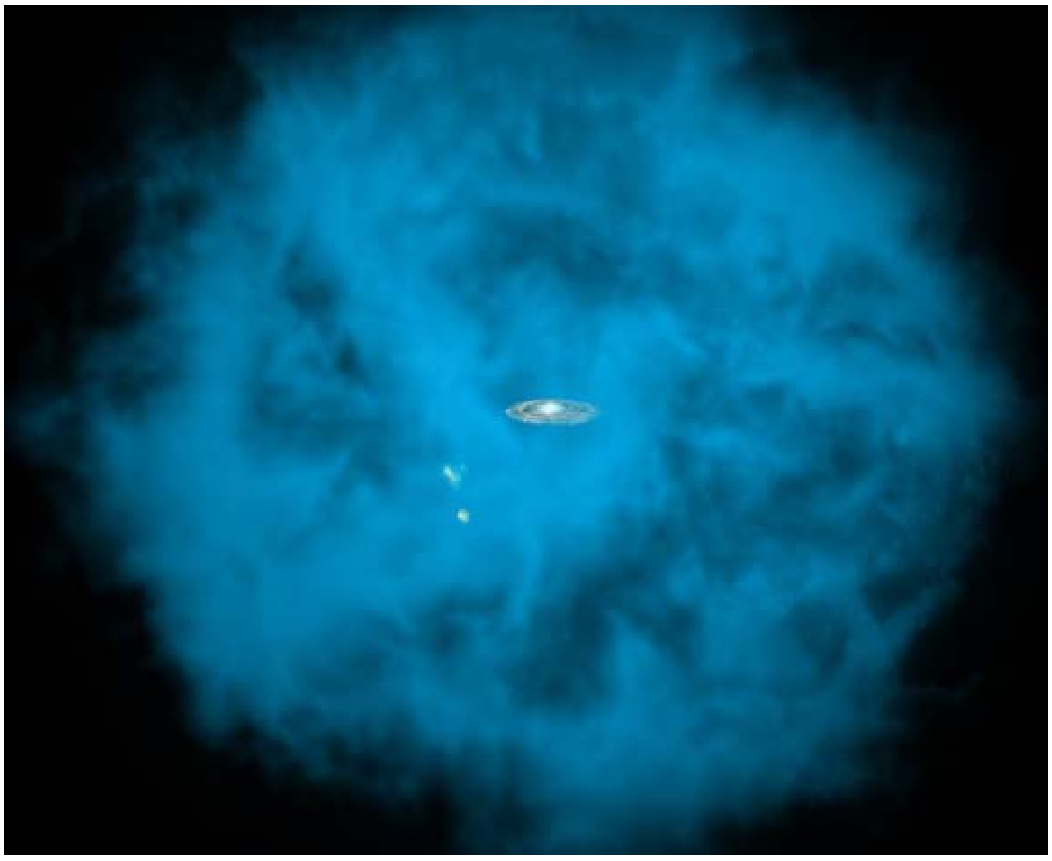
Posted on March 12, 2013 by Sean Carroll

Longtime readers know that I'm fascinated by the possibility that dark matter is "interesting." matter is by its very nature interesting, but I'm referring to the idea that the dark matter isn't neutral particle with a negligible rate of interaction in the current universe, but rather a set of of particles with some noticeable forces acting between them. Friends of mine and I have inve dark photons — dark matter being charged under a new "dark force" resembling ordinary elect next obvious step is dark atoms — two different kinds of charged dark particles that can join to atom-like bound states. These ideas, it turns out, are fairly compatible with what we know abo dark matter in the real universe.

Now a new paper by JiJi Fan, Andrey Katz, Lisa Randall, and Matthew Reece examines the pa astrophysical consequences of a somewhat more elaborate version of this idea, which they call Interacting Dark Matter." The idea is that most of the dark matter is vanilla and boring, but so atom-like. This has interesting implications for galaxies and small-scale structure. Here's the a

> ***Double-Disk Dark Matter***
> *JiJi Fan, Andrey Katz, Lisa Randall, Matthew Reece*
>
> *Based on observational tests and constraints on halo structure, dark matter is general be cold and essentially collisionless. On the other hand, given the large number of par forces in the visible world, a more complex dark sector could be a reasonable or even l possibility. This hypothesis leads to testable consequences, perhaps portending the dis rich hidden world neighboring our own. We consider a scenario that readily satisfies bounds that we call Partially Interacting Dark Matter (PIDM). This scenario contains self-interacting dark matter, but it is not the dominant component. Even if PIDM cont fraction of the net dark matter density, comparable to the baryonic fraction, the subd component's interactions can lead to interesting and potentially observable consequen primary focus will be the special case of Double-Disk Dark Matter (DDDM), in which self-interactions allow the dark matter to lose enough energy to lead to dynamics simi in the baryonic sector. We explore a simple model in which DDDM can cool efficiently disk within galaxies, and we evaluate some of the possible observational signatures. T prominent signal of such a scenario could be an enhanced indirect detection signature distinctive spatial distribution. Even though subdominant, the enhanced density at th the galaxy and possibly throughout the plane of the galaxy can lead to large boost fac could even explain a signature as large as the 130 GeV Fermi line. Such scenarios also additional dark radiation degrees of freedom that could soon be detectable and would the interpretation of future data, such as that from Planck and from the Gaia satellite. consider this to be the first step toward exploring a rich array of new possibilities for dynamics.*

Most investigations of dark matter indicate that it is spread much more tenuously through the ordinary matter, which tends to clump together. The basic idea is illustrated in this artist's cor dark matter halo associated with our Milky Way galaxy and its Magellanic Cloud satellites. (**U** reading comprehension failure on my part. This is an artist's conception of hot gas around the dark matter, as Peter Edmonds pointed out on Twitter. But they look similar!)



There is a straightforward explanation for this behavior: ordinary matter feels the electromagn atoms can bump into each other and release energy by radiating photons, which lets them "co into relatively dense clumps (like galaxies and even stars). Standard dark matter particles have interactions indeed, so when they fall into a gravitational potential well they just zip through t without cooling, giving the dark matter distribution a much puffier profile.

Here Fan *et al.* are suggesting that part of the dark matter could form atoms and cool, allowin efficiently in the centers of galaxies. This could lead to more frequent dark-matter annihilatior otherwise expect, which might be suggested by some tantalizing observational results (althou tentative).

It's fun to think about, although we're far away from drawing any firm conclusions at the mom know how to test these ideas observationally unless we work out their predictions theoreticall complicated universe, we need to be prepared.

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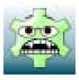
21 Responses to *More Messy Dark Matter*

Platohagel *says:*
March 12, 2013 at 1:12 pm

Are you suggesting a connection, as a basis with regard to Cosmic strings?

meh *says:*
March 12, 2013 at 3:47 pm

meh



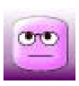
CoffeeCupContrails *says:*
March 12, 2013 at 7:04 pm

Hi, Sean. Always interesting to read a such a digestible article on this subject.

Does this interesting notion of (some family of) DM particles possibly interacting with each other in a g
suggest that the radiation emitted by the black hole at our galactic center might possibly contain some s

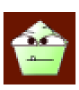
For that matter (uggh…!), could the twisted space-time constituting all black holes also be dark matter
sense that there would be an increased probability of DM particles interacting in the restricted space ar

In my mind, the closest analogy I can draw are two H atoms zipping around at Room Temp. and their r
any detectable kind) made more likely in any constrained space and near-infinite time.



Sean Carroll *says:*
March 12, 2013 at 9:35 pm

Anywhere the density of dark matter is high, you can get annihilation signatures. Near a black hole is c
possibility. (But you wouldn't expect the density to be extremely high there, since the dark matter woul
the hole.)



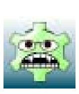
BobC *says:*
March 12, 2013 at 9:47 pm

> *" Standard dark matter particles have very weak interactions indeed, so when they fall into a g
> potential well they just zip through the other side without cooling, giving the dark matter distr
> puffier profile."*

Does this mean dark matter is turbulent?

I truly enjoy elegant word-pictures that permit me to grok a concept without having to wade through th

Got one for the Higgs-weak interaction?



CoffeeCupContrails *says:*
March 13, 2013 at 5:58 am

Ah! So the task for experimentalists would be to determine where the DM density might be high.

Last question (I promise)
But how do we 'know' that annihilation signatures might be stronger if the DM density were higher? W
based on high density interactions of regular matter? Isn't it true that the only observations we've made
related?

What I mean is, is it worthwhile to speculate that high density of DM might neutralize any such effects
little of their local interactions – and that low density (long range) interactions might instead be the no
gravity at galactic scales. [Emergent phenomena, etc etc]

I'm certain I missed some part of the DM conversation about expected local interactions; if so, feel free speculation! This is so fascinating.

Alexander McLin *says:*
March 13, 2013 at 6:32 am

In this model, does the DDDM still interact with the ordinary dark matter via non-gravitational forces? gravity, isn't we really talking about two dark sectors?

Still fascinating! Here we have actual evidence of whole sectors existing beyond our familiar world, and people sprouting nonsense about astral planes and all that. Only if they'd just pause and actually look u actual universe is just as cool if not even better.

Are DDDM particles still their own anti-matter?

N. *says:*
March 13, 2013 at 12:45 pm

You have your dark matter.

I vote for MOND.

Brett *says:*
March 14, 2013 at 6:11 am

Ugh, I regret to inform you that I vote for MOND as well. It's a lonely life.

Larry Matthews *says:*
March 15, 2013 at 6:22 pm

The messiest thing about dark matter is its name, which hardwires explanations. If oceans had been ca would still be debate on how much dirt was in them.

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crd2 *says:*
March 15, 2013 at 10:03 pm

@ n. & Brett: If you think MOND makes more sense as an overall theory than dark matter does your no story. MOND is very good at one specific thing (galaxy rotation), DM covers a broader range of issues &

DanielS *says:*
March 16, 2013 at 8:17 am

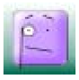
I bet on black matter as the gravitational connection with the multiverse.

The searcher *says:*
March 16, 2013 at 5:08 pm

Hi Sean,
happy that I found you, after long research.

I'm just a researcher that is looking in space and time for the ultimate answer.
I would love to mention your articles and make a link exchange, if you want.

Kind Regards,
The Researcher



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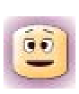
The Researcher
http://www.theresearcher.org

Ben *says:*
March 17, 2013 at 1:35 am

@cr2 et al.: nobody seems to realize that these days, "MOND" also means "some more complex form o the usual WIMP, one that is fully empirically motivated because it is built to actually explain galaxy ph bottom-up rather than top-down approach). In that sense, it is perfectly sensible to vote for MOND, bu realizes that it is also another kind of "more messy dark matter", but whose messiness can actually exp (at the moment) dont make sense otherwise: there are a few examples of such MOND theories, the mo currently being, IMHO, http://arxiv.org/abs/0901.3114 , which passes the CMB and large-scale structu with brillo, and might make some contrarian predictions on non-gaussianities http://arxiv.org/abs/121 interesting to look for.

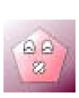
Gizelle Janine *says:*
March 17, 2013 at 2:06 pm

Sort of off the subject: Sean- The new book is awesome, and very well written, I must say! Great job!



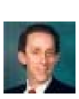
Joe/Emily *says:*
March 18, 2013 at 12:42 pm

Speaking of messy (dark) matter...why ya gotta be such a cockblock? We (respectfully) demand a telep STAT.



James Goetz *says:*
March 21, 2013 at 10:16 pm

I could accept the existence of dark particles only if we live in a zero-dark-particle universe with an eq particles and anti-dark particles.



Thomas J. Buckholtz *says:*
March 25, 2013 at 10:55 am

Sean:

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Permit me to offer a reasonably well-defined conjecture as to the nature of dark matter. Dark matter co
“ensembles” of “stuff,” with each ensemble being quite similar to the “baryonic-matter ensemble” of stu

.

Indeed, “adequately physics-savvy beings,” (in any of the 6 ensembles) would …
* Measure most properties of “their” elementary particles to be similar to properties we ascribe to bary
(Exceptions could include parity and handedness.)
* Consider that there are 5 ensembles of “dark matter.” (Yes, we could be part of some beings’ “dark ma

.

The above conjecture results from a symmetry that I identify while attempting some research. I heard i
Einstein (while developing special relativity) posed a question somewhat to the effect of ‘what can I lea
travelling along with a light wave?’ I explored quantum mechanics related to the same question. I find a
mechanical representation for photon states. There is a 6-fold symmetry. I generalize (yes, there are m
discuss here) to the notion of ensembles of similar stuff. Each ensemble has a complete set of tradition
(except “gravitons”) and does not share the corresponding boson-mediated forces with other ensemble
ensembles shares gravity, another type of zero-mass boson (which likely is responsible for the current i
expansion of the universe), and some possible spin-2 relatives of the traditional weak-interaction boso
relatives may have been responsible for matter/anti-matter imbalance in baryonic matter – and in the
mentioned above.)

.

The research points to yet more symmetry and thereby indicates possibilities for 4 or 8 such groups of
Presumably, 3 of the “other such groups” provide a candidate explanation for dark-energy density-of-t
No 2 such groups of 6 ensembles share gravity or “increase the rate of expansion” bosons. But, they do
conjectured bosons.

.

For more information, perhaps you will want to consult the video at http://thomasjbuckholtz.wordpres
/14/are-we-part-of-other-beings-dark-energy/ . It is (minus the first and last slides) a draft of the “Dar
Fermions” talk I plan to give at the American Physics Society meeting in Denver in April. (I need to cha
neutrino masses to indicate the mass shown is one of a few candidates.) The book “Physics Small and V
detail about the research.

.

I would be happy to make your acquaintance and discuss this further.

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Also, permit me to note that you and I share linkage to Caltech. My wife Helen and I are life members o
and I met as graduate students in the physics department at Berkeley. I had earned a B.S. in math from

Federico *says:*
March 25, 2013 at 2:27 pm

Re: March 12, 2013 at 9:35 pm
I have a naive question regarding very weakly interacting DM falling into a BH: wouldn’t some DM act
through? Say, if it has an impact parameter somehow smaller than the Schwarzschild radius. Classicall
momentum conservation to work, but I don’t know if these arguments still apply here.

jochem van der spek *says:*
March 30, 2013 at 1:58 am

Dear Sean, are there any theories that describe dark matter not as ‘stuff’ but as ‘bumps’ in space itself, p
the same manner as the ‘bumps’ in the temperature variations of the cosmic background radiation ? If s
some pointers ?

Jonathan