Comment on "Dispersion Velocity of Galactic Dark Matter Particles"

In a recent Letter [1], Cowsik *et al.* claim that a self-consistent treatment of the dark halo of the Galaxy, which takes into account the gravitational effect of luminous matter and allows for nonsphericity, requires that the local velocity dispersion of dark-matter particles be 600 $\mathrm{km\,s^{-1}}$ or greater, more than a factor of 2 larger than the canonical value of 270 $\mathrm{km\,s^{-1}}$. If true, this would significantly affect rates and signature for detection of baryonic and nonbaryonic dark matter.

This work contradicts the assembled results of a long history of work in Galactic dynamics, which among other things holds that the velocity dispersion of the halo should be close to 270 $\mathrm{km\,s^{-1}}$, the value that obtains for a spherically symmetric isothermal halo, $\sqrt{3/2}$ times the asymptotic rotation velocity of around 220 $\mathrm{km\,s^{-1}}$. We believe that this work is incorrect, probably because not all the observational constraints were taken into account and because the models were forced to satisfy an arbitrary constraint on the halo density.

Cowsik *et al.* construct their models for the distribution of halo dark-matter particles by assuming an isothermal (i.e., Maxwell-Boltzmann velocity distribution with a constant disperison), axisymmetric distribution of dark-matter particles that move in the combined gravitational potential of the bulge, disk, and halo. They solve the coupled Boltzmann and Newton equations iteratively, subject to the arbitrary boundary condition $\rho_{\mathrm{DM}}(r = 8\ \mathrm{kpc}) \sim 0.3\ \mathrm{GeV/cm^3}$. We call this arbitrary because the density of dark-matter particles at the solar circle is not measured, but is derived from Galactic models. They derive a velocity dispersion by fitting the calculated equatorial rotation curve for the model to the data from 2 to 18 kpc, and find that a value of at least 600 $\mathrm{km\,s^{-1}}$ is required.

While their models may do well in reproducing the inner rotation curve, they conflict with several important observational facts: (1) In the neighborhood of the solar circle the velocity dispersion of the halo has been estimated from velocity measurements of halo stars and globular clusters and is found to be around 200 $\mathrm{km\,s^{-1}}$ [2], in severe conflict with their velocity dispersion of 600 $\mathrm{km\,s^{-1}}$. (2) The rotation curves for several of their preferred halo models exceed 250 $\mathrm{km\,s^{-1}}$ at 20 kpc and all continue to rise to an asymptotic value of around $\sqrt{2/3} \times 600\ \mathrm{km\,s^{-1}} \sim 500\ \mathrm{km\,s^{-1}}$. This conflicts with determinations of the rotation speed ($\simeq 200-250\ \mathrm{km\,s^{-1}}$) at distances from 50 to 100 kpc based upon the proper motions of the Milky Way's satellites (LMC at 50 kpc, Pal 3 at 79 kpc, and Sculptor at 95 kpc). (3) Based upon the velocities of the fastest moving halo stars, the escape velocity from the Galaxy is determined to be between 450 and 650 $\mathrm{km\,s^{-1}}$. Even if the halo velocity dispersion—which is also the rms velocity—were once 600 $\mathrm{km\,s^{-1}}$, it would not remain so.

Finally, others have studied the effect of the bulge and disk on the halo as well as flattening of the halo and find that they do not change the velocity dispersion of the halo significantly. That the bulge and disk do not affect the halo is easily understood: The mass of the bulge is small ($\sim 2 \times 10^{10} M_\odot$) and so its effects are restricted to near the center of the Galaxy; the velocity dispersion within the disk is only around 30 $\mathrm{km\,s^{-1}}$. While flattening the halo can increase the local halo density [3], it can be shown by use of the virial theorem that it does not significantly affect the velocity dispersion. Kuijken and Dubinski [4] find that the local halo velocity dispersions in several self-consistent models for the disk, bulge, and halo of the Milky Way range from 246 to 323 $\mathrm{km\,s^{-1}}$.

We do not know where Cowsik *et al.* went wrong. However, we are confident that their lower limit to the dark-matter velocity dispersion is incorrect because the models upon which it is based conflict with a variety of observations and because previous work found that the effect of the luminous matter on the halo was small.

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