Comment on "Calorimetric Dark Matter Detection with Galactic Center Gas Clouds"

In a recent Letter, Bhoonah *et al.* [1] attempted to derive limits on dark matter interactions with ordinary matter by demanding that dark matter (DM) heating of gas clouds not exceed the known astrophysical cooling rate based on the temperature, density, and metallicity of the observed clouds. In Ref. [1], the cloud G1.4–1.8 + 87 from Ref. [2] was singled out as most suitable by virtue of its apparently exceptionally low temperature and relatively low density. In this Comment, we point out a fundamental conceptual error in Ref. [1]—namely, their use of clouds in the high-velocity nuclear outflow (HVNO) of the Galaxy for the analysis. This, along with additional detailed errors, invalidates the limits reported in Ref. [1].

The conceptual error in Ref. [1] is their use of complex, poorly understood, and likely-short-lived clouds for placing limits. The HVNO clouds are in the hot, high-velocity wind ($10^{6–7}$ K, 330 km/s) emanating from the Galactic Center. This extreme environment causes shocks and other destructive effects, likely making the clouds transient objects [3–10]. However, deriving DM bounds based on heat transport requires the system to be in a steady state at the current temperature over the long timescales associated with its purported radiative cooling rate, invalidating the use of a system for which the required stability is doubtful. The subsequent more detailed analysis of Bhoonah *et al.* [11] also ignores the effect of the extreme environment on the HVNO clouds and hence suffers from the same fundamental problem.

A further problem is that Ref. [1] calculated the temperature of G1.4–1.8 + 87 to be $T_g \lessapprox 22$ K by taking the velocity dispersion to be 1 km/s. Figure 1 shows the HI spectrum at the location of the cloud G1.4–1.8 + 87, from the public online data [12]. As seen in Fig. 1, most of the HI emission for this cloud is characterized by a line with a FWHM of 26.6 km/s (red line), with the narrow 1 km/s spike being a single-channel fluctuation [13]. For comparison, the spectrum of a robust cloud G33.4-8.0 [15], used in Ref. [16], is also shown. Using the correct width 26.6 km/s gives T_g above 15 000 K. Some other parameters given in Ref. [1] for the cloud G1.4–1.8 + 87 are also in error: Ref. [1] quotes the mass and radius of cloud to be 311 $M_\odot$ and 12 pc, whereas the correct values in Ref. [2] are 17 $M_\odot$ and 8.2 pc. The incorrect values of Ref. [1] appear to have been read from adjacent lines of the table in Ref. [2]. The cooling function drops drastically for $T < 100$ K, so the net effect of correcting the temperature and the density is that the radiative cooling rate of G1.4–1.8 + 87 increases by a factor $\approx 10^6$, and thus the conclusions drawn by Ref. [1] from G1.4–1.8 + 87 are incorrect, even if using HVNO clouds were legitimate.

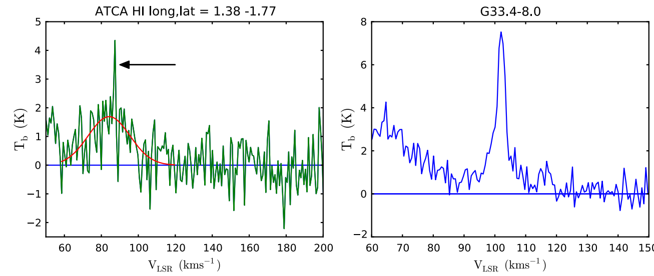

FIG. 1. (Left panel) The HI brightness temperature spectrum in the direction of G1.4–1.8 + 87. An arrow marks the extremely narrow line quoted in the table of Ref. [2], while the smooth curve shows a more appropriate Gaussian fit to the emission feature. (Right panel) The corresponding spectrum for G33.4–8.0 [15].

Two other errors in Ref. [1] need mentioning to avoid having others follow their example. First, Ref. [1] confuses the velocity of the cloud relative to the local standard of rest $V_{\rm LSR} = 87$ km/s, reported in Ref. [2], with the velocity of the cloud relative to the Galaxy's center of mass. $V_{\rm LSR}$ is defined to be an object's line-of-sight velocity relative to a frame of reference in a circular orbit around the Galactic Center at the position of the Solar System. Instead, the velocity of the cloud relative to the Galaxy is, to a good approximation, the outflow velocity of the HI clouds entrained in the nuclear wind, ~330 km/s from Ref. [17].

Second, a conservative bound requires adopting the smallest local DM density consistent with observations, which near the Galactic Center is generally given by the Burkert profile [18]. Reference [1] takes incorrect parameter values which exaggerate the Burkert density by a factor of 9 (without citing a source), $\rho_b = 14$ GeV/cm^3 and $r_b = 3$ kpc, instead of $\rho_b = 1.57$ GeV/cm^3 and $r_b = 9.26$ kpc from the latest fit [19]; the expression quoted in Ref. [1] for the form of the Burkert profile is also incorrect.

Limits on DM scattering from the cooling of suitable Milky Way clouds, and new and complementary constraints on DM from the Leo T dwarf galaxy, are reported in Ref. [16]; a more detailed discussion of HVNO clouds is given in its Supplemental Material [16]. The limits from robust Galactic clouds are 10^2 and 10^3 times less stringent for the millicharge parameter ϵ and the DM-nucleon scattering cross section, respectively, than claimed in Ref. [1] (see Ref. [16]).

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