Consistent dark matter interpretation for CoGeNT and DAMA/LIBRA

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In this paper, we study the recent excess of low-energy events observed by the CoGeNT Collaboration and the annual modulation reported by the DAMA/LIBRA Collaboration, and discuss whether these signals could both be the result of the same elastically scattering dark matter particle. We find that, without channeling but when taking into account uncertainties in the relevant quenching factors, a dark matter candidate with a mass of approximately 7 GeV and a cross section with nucleons of $\sigma_{\mathrm{DM-N}} \sim 2 \times 10^{-4}$ pb (2×10^{-40} cm^2) could account for both of these observations. We also comment on the events recently observed in the oxygen band of the CRESST experiment and point out that these could potentially be explained by such a particle. Lastly, we compare the region of parameter space favored by DAMA/LIBRA and CoGeNT to the constraints from XENON10, XENON100, and CDMS (Si) and find that these experiments cannot at this time rule out a dark matter interpretation of these signals.

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I. INTRODUCTION

For nearly a decade, the DAMA Collaboration (and more recently, the DAMA/LIBRA Collaboration) has reported an annual modulation in their event rate and interpreted this signal as evidence for particle dark matter. According to their most recent results, which make use of over 1.17 ton-years of data, the DAMA/LIBRA Collaboration observes a modulation with a significance of 8.9σ, and with a phase consistent with that predicted for elastically scattering dark matter [1]. When the null results from other dark matter searches [2,3] are taken into account, one is forced to consider very light dark matter particles ($\lesssim 10$ GeV) to accommodate this signal [4].[1]

Recently, the CoGeNT Collaboration has announced the observation of an excess of low-energy events relative to expected backgrounds [8]. This excess, if interpreted as dark matter, implies the dark matter particles possess a mass in the range of 5–15 GeV and an elastic scattering cross section with nucleons on the order of 10^{-4} pb (10^{-40} cm^2). These implied values are remarkably similar to those needed to generate the annual modulation reported by the DAMA/LIBRA Collaboration [9].

Dark matter interpretations of the combined DAMA/LIBRA and CoGeNT signals have, however, been somewhat controversial. One reason for this is that it has been claimed that the regions of dark matter parameter space (mass vs cross section) implied by CoGeNT and DAMA/LIBRA do not overlap, unless channeling occurs in the DAMA/LIBRA apparatus [8,10–14]. This problem has been exacerbated by recent theoretical work which suggests that the effects of channeling in DAMA/LIBRA should be much smaller than previously considered [15] (even if some model-dependence remains). Another source of controversy has resulted from the null results of other dark matter searches, including XENON100, XENON10, and CDMS (Si) [3,10,11,16].

In this paper, we revisit these and related issues in an attempt to determine whether the signals reported by the DAMA/LIBRA and CoGeNT Collaborations could potentially originate from the same dark matter particle without conflicting with the null results of other experiments. In Sec. II, we calculate the regions of dark matter parameter space implied by DAMA/LIBRA and CoGeNT and determine that, if uncertainties in these experiments' quenching factors are taken into account, consistent regions do exist. In particular, the combination of DAMA/LIBRA and CoGeNT data can be well accommodated by a dark matter particle with a mass of approximately 7 GeV and an elastic scattering cross section with nucleons of $\sim 2 \times 10^{-4}$ pb (2×10^{-40} cm^2), even if no significant channeling is taking place. We also comment on the events recently observed in the oxygen band of the CRESST experiment. In Sec. III, we discuss the null results of other dark matter experiments, including XENON10, XENON100, and CDMS (Si), and find that none currently excludes the region favored by the combination of DAMA/LIBRA and CoGeNT. We summarize our result in Sec. IV.

[1]Alternatively, one could also consider scenarios in which dark matter particles interact with nuclei through a resonance [5], interact with nuclei with a momentum dependence causing them to scatter more efficiently with NaI than other targets [6], or interact with nuclei largely through inelastic processes [7]; any of these scenarios could plausibly generate the DAMA/LIBRA signal while evading all relevant null results.

II. CONSISTENCY OF COGENT AND DAMA/LIBRA

Since the first presentation of the recent CoGeNT results four months ago [8], several groups [10–14] have fit the observed spectrum of events to elastically scattering dark matter scenarios and compared these fits to those implied by the annual modulation observed by DAMA/LIBRA [1]. While these studies find that the CoGeNT and DAMA/LIBRA signals point to similar regions of dark matter parameter space, the regions were found to overlap only if the effects of channeling are significant within the DAMA/LIBRA detectors.

In channeled events, the crystal nature of the detector enables the total recoil energy to be detected, in contrast to ordinary nuclear recoil events in which only a fraction (known as the quenching factor) of the energy is deposited in observable forms (scintillation light, heat, and/or ionization) relative to that in electron recoils [17,18]. Recent theoretical work, however, appears to disfavor the possibility that channeling plays an important role in an experiment such as DAMA/LIBRA [15,16]. In particular, ions recoiled by a dark matter particle originate in lattice sites and will not approach the channels of the crystal, but instead are expected to be efficiently blocked by the crystal lattice. In light of these findings, we will assume throughout this study that the fraction of events that are channeled at DAMA/LIBRA (or in other direct detection experiments) is negligible.

The question we wish to address in this section is whether, without channeling, the CoGeNT and DAMA/LIBRA signals could both originate from the same dark matter particle species. With this goal in mind, we consider the systematic uncertainties involved in these experiments' results, in particular, those pertaining to the germanium and sodium quenching factors.

Following Ref. [19], the spectrum (in nuclear recoil energy) of dark matter induced elastic scattering events is given by

$$\frac{dR}{dE_R} = N_T \frac{\rho_{\rm DM}}{m_{\rm DM}} \int_{|\vec{v}|>v_{\rm min}} d^3v\, v f(\vec{v}, \vec{v}_e) \frac{d\sigma}{dE_R}, \qquad (1)$$

where N_T is the number of target nuclei, $m_{\rm DM}$ is the mass of the dark matter particle, $\rho_{\rm DM}$ is the local dark matter density, $\vec{v}$ is the dark matter velocity in the frame of the Earth, $\vec{v}_e$ is the velocity of the Earth with respect to the galactic halo, and $f(\vec{v}, \vec{v}_e)$ is the distribution function of dark matter particle velocities, which we take to be the standard Maxwell-Boltzmann distribution:

$$f(\vec{v}, \vec{v}_e) = \frac{1}{(\pi v_0^2)^{3/2}} e^{-(\vec{v}+\vec{v}_e)^2/v_0^2}. \qquad (2)$$

The Earth's speed relative to the galactic halo is given by $v_e = v_\odot + v_{\rm orb}\cos\gamma\cos[\omega(t-t_0)]$ where $v_\odot = v_0 + 12$ km/s, $v_{\rm orb} = 30$ km/s, $\cos\gamma = 0.51$, $t_0 =$ June 2nd, and $\omega = 2\pi$/year. We take $v_0 = 230$ km/s and limit the velocity distribution with a galactic escape velocity of 600 km/s [19]. The minimum dark matter velocity required to impart a recoil of energy, E_R, is given by $v_{\rm min} = \sqrt{E_R m_N / 2\mu^2}$, where m_N is the mass of the target nucleus and μ is the reduced mass of the dark matter particle and the target nucleus. Throughout our analysis, we take $\rho_{\rm DM} = 0.3$ GeV/cm^3.

For a spin-independent cross section between dark matter particles and nuclei, we have

$$\frac{d\sigma}{dE_R} = \frac{m_N}{2v^2} \frac{\sigma_n}{\mu_n^2} \frac{[f_p Z + f_n(A-Z)]^2}{f_n^2} F^2(q), \qquad (3)$$

where μ_n is the reduced mass of the dark matter particle and nucleon (proton or neutron), σ_n is the scattering cross section of the dark matter particle with neutrons, Z and A are the atomic and mass numbers of the nucleus, and $f_{n,p}$ are the coupling strengths of the dark matter particle to neutrons and protons, respectively. (We will assume that $f_p = f_n$.) The nuclear form factor, $F(q)$, accounts for the finite momentum transfer in scattering events. In our calculations, we adopt the Helm form factor:

$$F(q) = \frac{3j_1(qR_1)}{qR_1} e^{-(1/2)q^2 s^2}, \qquad (4)$$

where j_1 is the second spherical bessel function and R_1 is given by

$$R_1 = \sqrt{c^2 + \frac{7\pi^2 a^2}{3} - 5s^2}. \qquad (5)$$

Here, $c \approx 1.23A^{1/3} - 0.60$ fm, $a \approx 0.523$ fm, and $s \approx 0.9$ fm have been determined by fits to nuclear physics data [20,21]. Note that other commonly used parametrizations of the form factor can lead to modest but not insignificant (on the order of 10 to 20%) variations in the region of dark matter parameter space that provide a good fit to the CoGeNT (and to a lesser extent DAMA/LIBRA) signal.

While variations in the velocity distribution of dark matter particles could also significantly affect the quality of the fits found to the CoGeNT and/or DAMA/LIBRA data (see, for example, Ref. [22]), such changes tend to affect the fits to each data set in a similar way. Increasing v_0 and/or $v_{\rm esc}$, for example, will tend to move the acceptable regions of dark matter parameter space toward lighter masses (and smaller cross sections) for both CoGeNT and DAMA/LIBRA. Since both regions will be moved in approximate unison, we do not consider such variations further. Similarly, we do not contemplate any deviations from a standard isothermal dark matter halo, another source of possible uncertainty affecting the comparison of DAMA/LIBRA to other experiments [23].

Over the energy range of the CoGeNT signal (approximately 0.4–2 keVee, where keVee denotes the equivalent electron energy), a number of measurements have been made of the relevant quenching factors (i.e. the ratio of ionization energy to total recoil energy) [24,25]. These are summarized in Fig. 1. The solid line in this figure represents the best fit to the data shown, assuming a parametrization chosen to follow the Lindhard theory (using $k = 0.20$). The dashed lines reflect the 2σ statistical upper and lower limits. In our fits, we will adopt a quenching factor for germanium given by $Q_{\rm Ge}(E_{\rm Recoil} = 3\ {\rm keV}) = 0.218 \pm 0.0058$, and with the energy dependence predicted by the Lindhard theory. Note that this neglects any systematic errors, the inclusion of which would further enlarge the region of dark matter parameter space potentially capable of accommodating the CoGeNT signal.

For DAMA/LIBRA, measurements of the NaI(T1) quenching factors are often averaged over large ranges of energy, hindering efforts to quantify the uncertainties in the narrow energy range of interest for light dark matter particles. In particular, the DAMA/LIBRA Collaboration reports a measurement of their sodium (in the form of NaI, doped with thallium) quenching factor to be $Q_{\rm Na} = 0.30 \pm 0.01$ averaged over the energy recoil range of 6.5–97 keV [26]. Other groups have reported similar values: $Q_{\rm Na} = 0.25 \pm 0.03$ (over 20–80 keV), 0.275 ± 0.018 (over 4–252 keV), and 0.4 ± 0.2 (over 5–100 keV) [27]. As the sodium quenching factor is generally anticipated to vary as a function of energy, it is very plausible that over the range of recoil energies relevant for light (5–10 GeV) dark matter (approximately 5 to 20 keV) the quenching factor could be somewhat higher than the average values reported from these measurements [28] (see, for example, Ref. [29] and discussion in Ref. [30]). For recoil energies below approximately 20 keV, Ref. [31] reports a measurement of $Q_{\rm Na} = 0.33 \pm 0.15$, whereas Ref. [32] reports a somewhat smaller value of $Q_{\rm Na} = 0.252 \pm 0.064$ near 10 keV. A failure to account for the nonproportionality in electron response at low energy [33] appears in the energy calibration of several of these measurements, including those of Ref. [32]: the need for additional precision measurements of quenching factor near DAMA/LIBRA's threshold of 2 keVee seems evident. In our fits, we conservatively adopt a sodium quenching factor of $Q_{\rm Na} = 0.3 \pm 0.13$ over the energy range of interest ($E \approx 2$–6 keVee), which we deem representative of present experimental uncertainties.

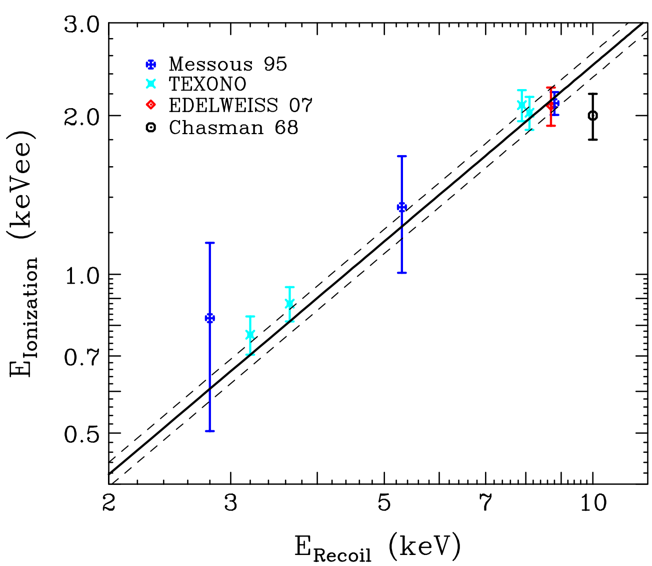

FIG. 1 (color online). Measurements of the germanium quenching factor ($Q_{\rm Ge} \equiv E_{\rm Ionization}/E_{\rm Recoil}$) over the energy range of the excess events observed by CoGeNT. The solid line denotes the best fit normalization to these measurements, assuming the slope predicted by the Lindhard theory ($k = 0.20$). The dashed lines represent the upper and lower 2σ normalizations, accounting only for statistical errors. For the measurements used, see Ref. [24]. Additional measurements by the CoGeNT Collaboration span down to $E_{\rm Recoil} = 0.7$ keV [25].

In Fig. 2, we show the regions of dark matter parameter space which provide a good fit to the DAMA/LIBRA and CoGeNT data separately (upper frame) and combined (lower frame). In performing our fits, we have used the (13) DAMA/LIBRA bins below 8.5 keVee and the (28) CoGeNT bins between 0.4 and 1.8 keVee. The data at higher energies will not include any events from dark matter particles in the mass range considered here, and the inclusion of higher energy bins would not affect our results in any significant way.

From Fig. 2, we see that there exists a range of masses and cross sections for which both DAMA/LIBRA and CoGeNT can potentially be accommodated. In the range of $m_{\rm DM} \sim 7$–8 GeV and $\sigma_{\rm DM-N} \approx (1\text{–}3) \times 10^{-4}$ pb, quite good fits can be found for both experiments.[2] The overlapping region requires fairly large values of the sodium quenching factors, $Q_{\rm Na} \approx 0.45$ or greater throughout the 99% CL region and $Q_{\rm Na} \approx 0.50$–0.55 in the 90% CL region, considerably larger than the measurements presented in Ref. [32]. In the upper frame of Fig. 3, we show the spectrum of events in CoGeNT for the case of $m_{\rm DM} = 6.8$ GeV and $\sigma_{\rm DM-N} = 1.58 \times 10^{-4}$ pb. The dashed line shows our background model, which consists of a flat spectrum combined with a well-understood double Gaussian peak (see Ref. [8] for details). In the lower frame of Fig. 3, we show the prediction for the same dark matter model compared to the spectrum of DAMA/LIBRA's annual modulation. From these plots, it is clear that both the CoGeNT and the DAMA/LIBRA signals could potentially result from an ~7–8 GeV dark matter particle with an elastic scattering cross section of $\sigma_{\rm DM-N} \approx (1\text{–}3) \times 10^{-4}$ pb.

Lastly, we briefly consider the spectrum of events reported in recent talks by the CRESST Collaboration [35]. In the data from 9 $CaWO_4$ crystals, with a total exposure of 333 kg-days, a larger than anticipated number of events

[2]An eventual stripping of L-shell electron capture peaks in the low-energy CoGeNT spectrum, based on high-statistics measurements of their K-shell counterparts and the known L/K capture ratio [34], is expected to favor precisely this same dark matter mass and cross section.

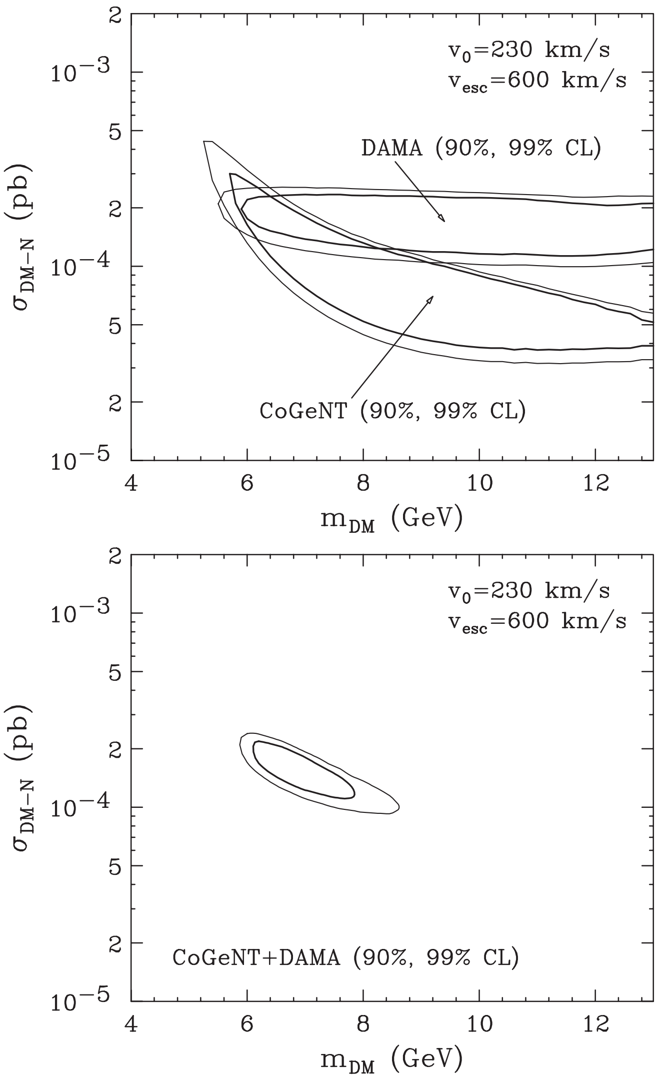

FIG. 2. The regions in the elastic scattering cross section (per nucleon) mass plane in which dark matter provides a good fit to the excess CoGeNT events and to the annual modulation reported by DAMA/LIBRA (upper frame), as well as the region in which the combination of CoGeNT + DAMA/LIBRA is well fit (lower frame). We have assumed that any effects of channeling are negligible and have adopted $v_0 = 230$ km/s and $v_{esc} = 600$ km/s. No errors associated with uncertainties in the form factors have been taken into account. If these and other systematics were fully included, the allowed region would be expected to increase considerably. See text for more details.

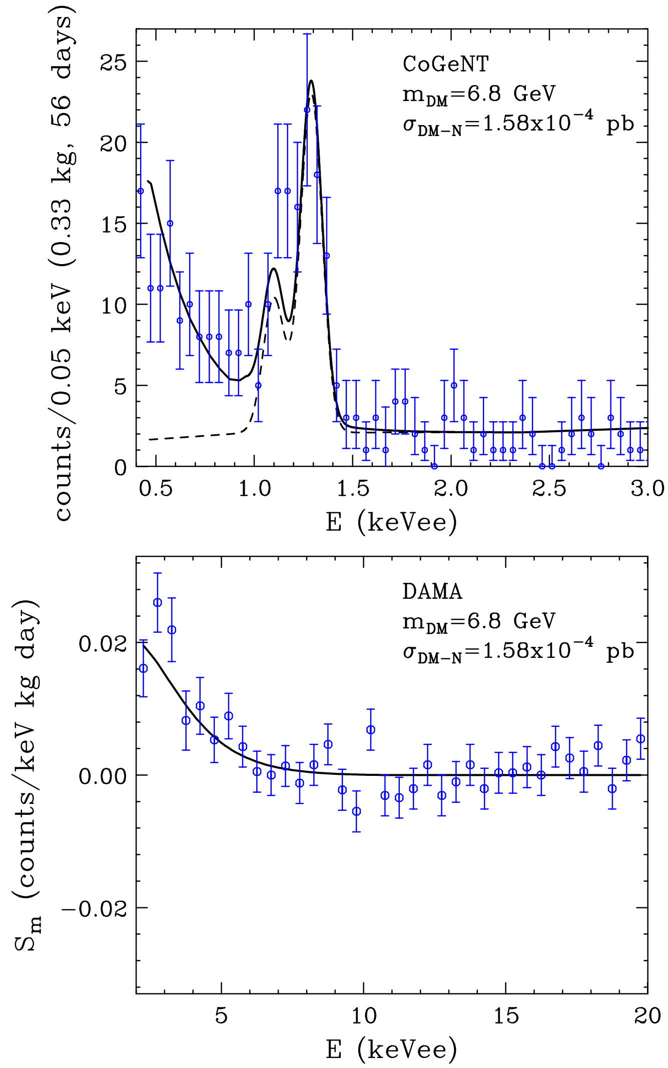

FIG. 3 (color online). The spectrum of events in CoGeNT (upper frame) and the spectrum of the annual modulation in DAMA/LIBRA (lower frame) for overall best fit dark matter parameters of $m_{DM} = 6.8$ GeV and $\sigma_{DM-N} = 1.58 \times 10^{-4}$ pb. In the upper frame, the solid black line is the predicted result for signal plus background (with triggering and signal acceptance efficiency built into the model), whereas the dashed line is the background alone and points denote the measured values. In the lower frame, the solid line is the predicted signal and the points denote the measurements reported by DAMA/LIBRA. We have assumed that any effects of channeling are negligible and have adopted $v_0 = 230$ km/s and $v_{esc} = 600$ km/s. See text for more details.

has been observed in the oxygen band of their experiment with recoil energies below ~20 keV. In Fig. 4, we show the spectrum of the oxygen band events reported in Ref. [35] and compare this to the spectrum predicted for a dark matter particle consistent with both CoGeNT and DAMA/LIBRA ($m = 6.8$ GeV, $\sigma_{DM-N} = 1.58 \times 10^{-4}$ pb). Note that, as the total exposure of the observation is not completely specified in Ref. [35], we have normalized the predicted curve (the solid line) to the data, which corresponds to an exposure (times efficiency) of 210 kg-days. Remarkably good agreement is found. For heavier dark matter particles, most of the dark matter events are expected to result from scattering with tungsten rather than oxygen nuclei. In the case of a very light dark matter particle, however, scattering with tungsten produces events with recoil energies below the threshold of the experiment. For this dark matter mass and cross section, we predict only one event in the tungsten band above 3.7 keV, and about ten events between 3.0 and 3.7 keV.

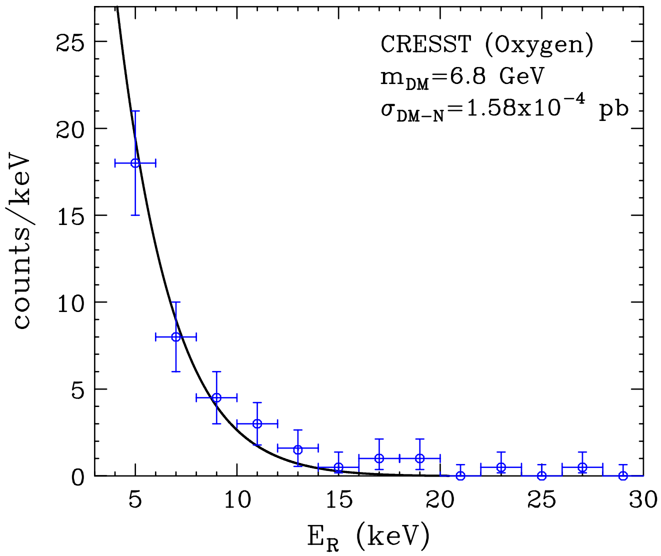

FIG. 4 (color online). The preliminary spectrum of events in the oxygen band of the CRESST experiment, compared to the spectral shape predicted for the case of $m_{DM} = 6.8$ GeV and $\sigma_{DM-N} = 1.58 \times 10^{-4}$ pb (which provides good fit to both CoGeNT and DAMA/LIBRA). The solid line is the predicted signal and the error bars denote the preliminary spectrum of events reported by the CRESST Collaboration. We have adopted $v_0 = 230$ km/s and $v_{esc} = 600$ km/s. See text for more details.

We would like to emphasize the preliminary nature of these results, and recognize that, until the CRESST Collaboration publishes their final distribution of events, fits to these data should be assessed with caution. In particular, we emphasize that some fraction of the events observed in the oxygen band could be spillage from CRESST's alpha or tungsten bands, be neutron backgrounds, or be the result of radioactive backgrounds. Further information from the CRESST Collaboration will be essential for understanding these results.

III. CONSISTENCY WITH NULL RESULTS

In this section, we discuss whether a dark matter interpretation of the combined CoGeNT and DAMA/LIBRA signals is consistent with the null results reported by other direct detection experiments. In particular, recent claims have been made that a dark matter interpretation of the CoGeNT and DAMA/LIBRA data are inconsistent with the measurements of the XENON100 experiment [3]. This conclusion depends critically, however, on the scintillation efficiency of liquid xenon, L_{eff}, that is adopted [16,30]. In particular, while both theoretical arguments and measurements of L_{eff} lead one to expect this quantity to decrease at low energies, no measurements exist below ~4 keV, forcing one to speculate or extrapolate at lower energies. Unless quite optimistic values for these quantities are adopted, the range of masses and cross sections best fit by DAMA/LIBRA and CoGeNT are not significantly constrained by XENON100 [30]. In fact, stronger constraints than those from XENON100 can be derived from the data of XENON10, due to its lower energy threshold [16] (see also Ref. [36]). The recent work of Manzur *et al.* provides measurements of L_{eff} over the range of approximately 4 to 70 keV [37]. By not taking into account Poisson fluctuations from dark matter signals below 4 keV, and thus not making any assumptions regarding the values of L_{eff} below this range, it is possible to arrive at the constraints shown in the upper frame of Fig. 5. These constraints yield only a mild tension (less than $\sim 1\sigma$) with

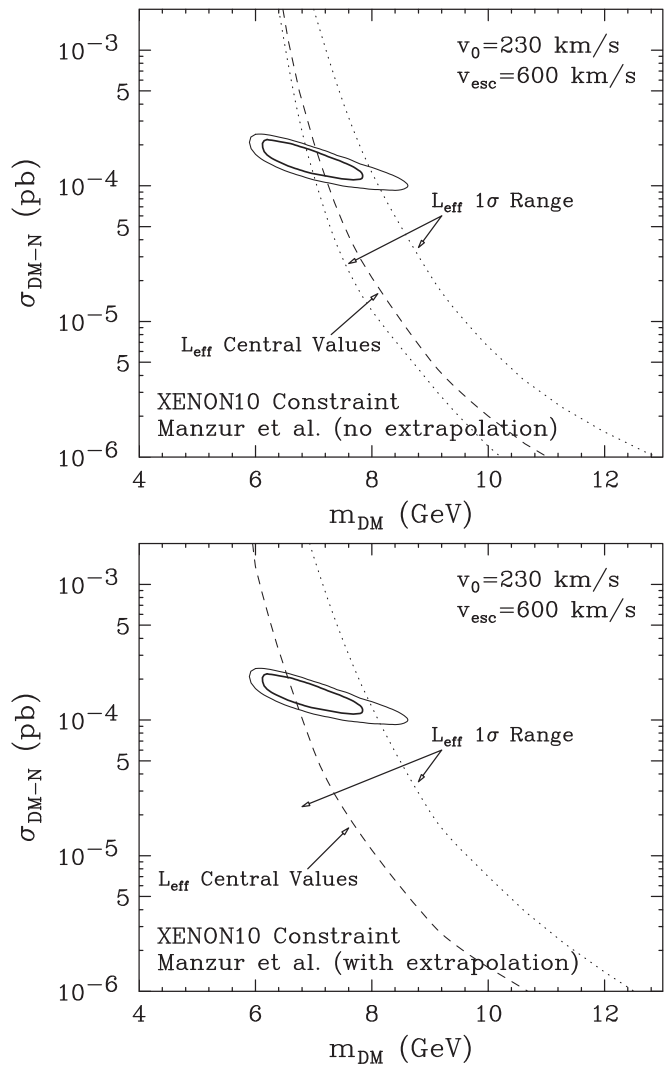

FIG. 5. Constraints from the XENON10 experiment [16]. In each frame, the dashed line denotes the limit when using the central values of the scintillation efficiency, L_{eff}, as measured by Manzur *et al.* [37], whereas the dotted lines are derived using $\pm 1\sigma$ values of L_{eff}. In the upper frame, no assumptions are made regarding the values of L_{eff} at energies below 4 keV (for which no measurements exist). In the lower frame, L_{eff} is assumed to fall linearly below 4 keV. Considerably more relaxed constraints are obtained from other existing measurements of L_{eff} [30]. See text for more details.

the parameter space region favored by DAMA/LIBRA and CoGeNT. If we instead assume that $L_{\rm eff}$ drops linearly below 4 keV, slightly stronger limits are found (Fig. 5, lower frame). Again, however, this constraint conflicts with the region favored by DAMA/LIBRA and CoGeNT at only about 1σ. We emphasize that other existing measurements and extrapolations of $L_{\rm eff}$ lead to a complete absence of constraints on the region of DAMA/LIBRA and CoGeNT compatibility, even when subthreshold Poisson fluctuations are assumed [30].

For typical dark matter masses, the null results from CDMS-II's germanium detectors provide the strongest constraints on the dark matter–nucleon elastic scattering cross-section [2]. Below ~10 GeV, however, the CDMS-II silicon detectors provide better constraints [38,39] due to the favorable kinematics of the lighter target nucleus. In Fig. 6, we compare these constraints to the regions favored by the dark matter interpretation of the combined DAMA/LIBRA and CoGeNT results. Taken as published (after accounting for the different velocity distribution used in Refs. [38,39]), we find that this constraint covers most of the 2σ range of masses and cross sections found to fit the DAMA/LIBRA and CoGeNT signals.

As noted in Ref. [38] (and as shown in their Fig. 3.20), however, the observed CDMS-II silicon nuclear recoil quenching is not reproduced by the Lindhard theory, and it is also markedly discrepant with previous measurements [40]. In contrast, an excellent agreement is observed for CDMS germanium detectors.[3] It is possible to attribute this disagreement to a systematic error in the absolute energy scale in the silicon detectors. The energy scale of the silicon detectors is more complicated than the germanium detectors to calibrate, since the silicon detectors are not thick enough to contain the full energy deposition from barium gamma rays used for calibration. Additionally, large corrections affecting the recoil energy scale are applied to the CDMS detectors to remove position dependences (see the discussion surrounding Fig. 3.18 of Ref. [38]). The discrepancy between the observed quenching and the Lindhard theory could indicate an ~20–30% error in the low-energy calibration, larger if other existing experimental data [40] are taken as the reference. In Fig. 6, we show how a corrected energy scale can change the constraints derived from the CDMS-II experiment, for the case of a linear 20% correction.[4] This shows that, while the CDMS-II silicon exposure could potentially constrain the region favored by DAMA/LIBRA and CoGeNT, this constraint is weakened due to the energy scale uncertainty and does not rule out the region favored by these experiments.

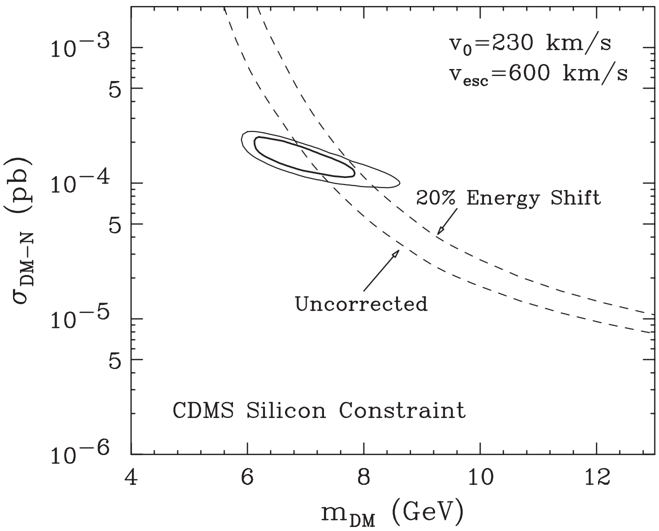

FIG. 6. Constraints from the CDMS experiment's silicon analysis. The lower dashed curve denotes the results as presented in Refs. [38,39], whereas the upper dashed curve shows the result with a 20% shift in CDMS's silicon recoil energy scale, a conservative correction that alleviates concerns expressed in the discussion surrounding Fig. 3.20 of Ref. [38]. See text for more details.

IV. SUMMARY AND DISCUSSION

In this paper, we have studied the excess of low-energy events recently reported by the CoGeNT Collaboration and the annual modulation signal reported by DAMA/LIBRA and conclude that these two signals could arise from an elastically scattering dark matter particle with a mass in the approximate range of 7 GeV and a cross section (with nucleons) of $\sigma \sim 1.58 \times 10^{-4}$ pb $(1.58 \times 10^{-40}\ \mathrm{cm}^2)$. This conclusion is reached even if channeling is assumed to be negligible. The concordance between these two signals, which has not been found in previous studies, is made possible in large part by our choice of nuclear form factors and our accounting for uncertainties in the quenching factors of germanium and sodium. We also point out that the preliminary events observed in the oxygen band of the CRESST experiment are consistent with being the result of such a dark matter particle.

We have also considered in this paper the constraints from null results of other direct detection experiments, including XENON10, XENON100, and CDMS (Si). After taking into account the uncertainties in the scintillation efficiency of liquid xenon and the recoil energy scale of silicon events at CDMS, we find that the region of dark matter parameter space favored by CoGeNT and DAMA/LIBRA is consistent with all current constraints.

[3] We remark without undue emphasis that a rough analysis of the CDMS germanium data in the relevant 2–5 keV recoil energy region exists [41].

[4] Note that a nonlinear energy correction would be needed to reconcile the Lindhard theory with the energies observed at CDMS-II. In particular, Fig. 3.20 of Ref. [38] shows the observed nuclear recoil band crossing the prediction from the Lindhard theory. The linear 20% correction used here, however, represents a reasonable estimate for the range of energies relevant for the detection of $\lesssim 10$ GeV dark matter.

In the future, it may become possible for the CoGeNT or CRESST experiments to observe an annual modulation in their rate. In particular, we calculate that if CoGeNT is observing dark matter interactions, their event rate should be approximately 20% higher in the summer than it is in the winter, for a particle of this mass and CoGeNT's energy threshold. To detect this effect with a significance of 3σ, an approximate exposure of 40 kg-days would be required in each of the summer and winter seasons. This goal appears to be attainable for the CoGeNT experiment, which has been operating continuously since December of 2009 with an active target mass of 0.33 kg. If observed, this would provide an important confirmation of the hypothesis that these experiments are in fact detecting dark matter.

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