Study and Analysis of Effective theory to direct detection of dark matter

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ABSTRACT　　*In this paper, the author broadens and investigates the general non-relativistic effective theory of dark matter (DM) direct detection. The author additionally depict the fundamental non-relativistic building squares of operators and examine their symmetry properties, recording all Galilean-invariant operators up to quadratic request in energy exchange emerging from trade of particles of turn 1 or less. Any DM molecule theory can be converted into the coefficients of a viable administrator and any powerful administrator can be just identified with most broad depiction of the nuclear reaction. A few operators which prompt novel nuclear reactions have been examined. These reactions contrast essentially from the standard insignificant WIMP cases in their relative coupling qualities to different components, changing how the outcomes from various trials ought to be looked at against each other. Reaction capacities are assessed for regular DM targets - F, Na, Ge, I, and Xe - utilizing standard shell show strategies. Likewise, the creator called attention to that every one of the nuclear reactions is natural from past investigations of semi-leptonic electroweak collaborations, and along these lines possibly testable in powerless connection examines. At last, a talk on implanting non-relativistic viable theory operators into UV models of dark issue has been made.*

Keywords: theory, direct detection, dark matter, operators.

INTRODUCTION

The nature of dark matter is a fascinating mystery that continues to be unsolved. Direct detection experiments offer the possibility of determining the precise interactions of a dark matter (DM) particle with nuclei. The analyses utilize diverse targets, conceivably testing different kinds of communications between the dark issue molecule and the core. Beforehand, there have been endeavors to misuse these contrasts between focuses, keeping in mind the end goal to accommodate potential signs seen at a few analyses [1] with the nonappearance of a flag at others. Nonetheless, thinks about are commonly performed in a model-driven manner, with the objective of putting requirements on a particular molecule show. As of late, [3] adopted an alternate strategy, by considering the main non-relativistic operators coupling DM to cores, and setting limits on their coefficients. This was done with regards to versatile dissipating. In this paper we might want to broaden this approach by going past the main operators to incorporate the full arrangement of conceivable operators in the non-relativistic theory, including force and speed subordinate operators also. The objective of this examination is to distinguish all conceivable flexible DM-core reaction works that might be misused by experimentalists to describe DM, and to relate these reactions to the hidden powerful theory operators that intercede the DM-customary issue connection.

Models with force subordinate collaborations have gotten some consideration of late, as they have decreased the strain between obviously clashing direct location tests [4]. Be that as it may, from a base up perspective, their allure is significantly more broad. At the present minute, nothing is thought about the non-gravitational collaborations of dark issue with the Standard Model, and as a rule, suspicions about couplings are driven absolutely by advances to moderation or particular models of the electroweak scale. Such standards are not really a decent guide regarding what we ought to expect for the idea of dark issue, and if the dark issue is rather as entangled as the Standard Model itself, at that point we may expect considerably more extravagant potential outcomes for its structure and communications. Specifically, if the dark issue is composite, as the majority of the noticeable issue in the universe is, at that point one ought to expect dark issue shape factors identified with their compositeness scale. From this point of view, force subordinate interactions are a convincing and very much spurred probability, since they require just a little measure of structure oblivious issue division. The standard contention against such reliance is that it will be smothered, since any force subordinate terms will fundamentally vanish in the farthest point of zero energy exchange at coordinate recognition tests. This anyway disregards the likelihood that the main, energy free communications can without much of a stretch be stifled or compelled to vanish, leaving the force subordinate collaborations as the predominant ones.

As opposed to creating all such conceivable models one by one, it is more proficient to pass specifically to a successful field theory portrayal. By and large, such a depiction is the most characteristic and proficient instrument to perform base up, demonstrate autonomous examinations. For this situation, the suitable viable field theory for coordinate identification tests includes an arrangement of fourfermion operators for

the connections of dull issue with a nucleon in the core in the non-relativistic utmost. The full arrangement of such operators, being higher-arrange in the energy, have likewise not been thought about beforehand. Curiously, as we will see, a portion of these operators prompt novel nuclear reactions, and thusly new shape factors are expected to portray DM interactions with the core. Specifically, coordinate location ought to incorporate not simply turn free and turn subordinate connections, yet additionally precise energy subordinate, and in addition turn and rakish force subordinate communications. Under this new system, the different components utilized for coordinate discovery, couple with various qualities, contingent upon their nuclear properties. It subsequently winds up critical to check whether current direct identification tests have a "blind side" when consolidated. To be specific, regardless of whether there are any operators (or blends of operators), which render dark issue less unmistakable to the as of now accessible targets [5].

EFFECTIVE THEORY FOR DIRECT DETECTION

The DM velocity in the galactic halo is typically of the order $v \sim 10-3$. For DM and target nuclei with mass around the weak scale, this implies incident DM kinetic energy and recoil energy around 10 keV, much smaller than typical nuclear binding energy (1 - 10) MeV per nucleon. This justifies the treatment of DM scattering against the whole nucleus using NR quantum mechanics. In our structure, the DM-core cooperation is depicted by a successful potential, Veff. It is a rotationally invariant scalar shaped out of four 3-vectors: the relative speed ~v, DM position ~r, DM turn ~sχ and nuclear turn ~sN . The case in which ~sN does not show up is known as turn autonomous (SI) dissipating, rather than turn subordinate (SD) dispersing. To the primary request of the Born guess, the sufficiency in as far as possible is the Fourier change of the powerful potential in position space [6]:

The mass scales that go into the potential are the DM mass mχ, the core mass mN , and the arbiter mass mφ. What's more, there could be different scales Λ0 exhibit. For example, the DM-middle person association could emerge at the non renormalizable level, encoded by a high dimensional administrator smothered by forces of Λ0 . This could happen, for instance, in models of DM with zero electric charge yet higher-arrange electromagnetic frame factors. Notice that immediate location tests compel one mix of the mass scales and the coupling constants. Along these lines, in the accompanying parameterization of NR viable theory, we ingest the majority of the scale reliance into the coefficients of the terms in the viable potential.

We have accepted a subsidiary development in ~r, comparing to forces of ~q in energy space. Along these lines, for example, a 1/r3 term is precluded on the grounds that it relates to a log |~q| collaboration. Logarithmic reliance on |~q| signals the trading of a continuum of modes, and could emerge if both DM and the SM couple to another massless or conformal area (which could have a mass scale far underneath alternate scales in the issue). Such parts have gotten consideration in the pretenses of RS2 [7] and unparticles, yet we don't know about models of such an area intervening associations amongst DM and the SM. A log |~q| reliance would have genuinely gentle impacts on the state of q the backlash vitality circulation, which is liable to vulnerabilities including nuclear material science and the DM speed conveyance, so we expect that it would be greatly testing to find prove for another conformal area exclusively from DM coordinate location.

Presently we might want to assess generally how huge the CP disregarding coupling could be if the CP infringement is bound to the obvious division. CP-abusing stages in the unmistakable area could be available in different augmentations of the SM. They blandly must be little to abstain from creating electric dipole minutes for the neutron, electron, and particles in struggle with watched information. For example, in the negligible supersymmetric SM, a mix of complex periods of the gaugino-mass parameters, the A parameters, and μ must be not as much as the request of 10−2 – 10−3 (for a supersymmetry-breaking size of 100 GeV). In the event that a CP damaging coupling like π 0 qq¯ with π 0 a pseudoscalar is created at one circle, the coupling might be additionally smothered by the circle factor. Considering other conceivable little couplings, one could get values in the range 10−5 – 10−7. Intriguingly, this is around the bound set by coordinate recognition [8].

THE NUCLEAR RESPONSES

The non-relativistic effective theory treatment of dark matter responses connects naturally to the standard language of multipole expansions for nuclear electroweak responses that we summarize here. Such developments enable one to abuse nuclear choice standards in light of rotational invariance, equality and time inversion. We practice here to the instance of versatile dark issue collaborations, as the vitality moves in dark issue diffusing by and large block inelastic excitations. (In any case, the augmentation of the multipole formalism to inelastic dull issue connections is clear and will be introduced somewhere else.) The great surmised equality and CP of the nuclear ground state at that point force imperative new choice

principles on the conceivable flexible operators, confining the multi-polarities that contribute and their impedance [9].

Nuclear Charges and Currents

The typical development of arrange space nuclear charge and current densities in electroweak collaborations starts with a covariant cooperation that is lessened to create the required nonrelativistic operators. The powerful theory approach fundamentally improves this investigation, and furthermore gives vital direction to the individuals who should need to take after a model-subordinate examination in light of some predefined covariant connection. Our beginning stage is the cooperation As we have examined beforehand, the Hermitian speed $v \perp$ can be isolated into an objective center of-mass piece $\sim v_\perp$ T and segments $\sim v_\perp$ N related with the relative speeds of target nucleons (and in this manner with the A-1 Jacobi momenta) [10].

While on a basic level the main, expressly Galilean invariant frame for the inherent hub charge administrator – a two-body administrator in relative directions – could be utilized in estimations, by and large the more straightforward one-body shape can be utilized given the focal point of-mass movement of the core is appropriately treated. Along these lines the understanding of the inherent subscript on the hub charge administrator above is a direction that such advances ought to be taken, if this type of the administrator is utilized. This is commonly done by working in a translationally-detachable (e.g., full shell) symphonious oscillator Slater determinant premise, at that point numerically driving the focal point of-mass to dwell in the 1s express: the confinements of this approach are examined in the reference section [11].

Leeway of the viable theory treatment is that it instantly distinguishes the translationally invariant force pivotal charge commitment to dark issue disseminating relative to $\sim v_\perp$ T . For versatile diffusing, this is the main commitment of the pivotal charge: framework components of the inborn administrator vanish for even multipoles by equality and for odd multipoles by time inversion. This outcome would be more hard to get in traditional medications that start with a covariant communication. Such estimations would need to extricate the force term from the pivotal charge administrator (as opposed to having it clearly in the point-core utmost of the effective administrator), an errand regularly requiring the consolidating of charge and current commitments [12].

DISCUSSION AND FUTURE DIRECTIONS

The exact nature of dark matter remains as yet unknown, and little can be said for certain about its interactions with the Standard Model. Particularly when looking at the outcomes from various investigations, it is in this way judicious to keep a receptive outlook about what shape such associations can take, and to dodge biases about fundamental models when conceivable. The most productive apparatus for isolating out presumptions about UV material science and parametrizing the important low-vitality potential outcomes is powerful field theory, which we have connected here to the immediate discovery of dull issue. Effective field theory has been considered in the specific circumstance, the most exhaustive investigation likely being [13]; be that as it may, the full arrangement of conceivable collaborations, including every single subordinate coupling and force smothered connections, and additionally the likelihood of obstruction between various operators, has not beforehand been investigated. Since guide location tests are delicate to connections with limited energy exchange, it is completely conceivable and all around inspired for force autonomous operators to be missing, and for force subordinate communications to be in charge of the main wellspring of direct discovery dispersing.

Notably, the full arrangement of potential outcomes is substantially more extravagant than the standard cases, and can support nuclear cores in a subjectively extraordinary manner. We have methodicallly built the low-vitality, non-relativistic powerful field theory depicting direct recognition scrambling. We have given careful consideration to the fundamental nonrelativistic building hinders, that interface specifically to significant test observables, and to their symmetry properties. This rearranges the distinguishing proof of all conceivable non-relativistic operators and makes their elucidation more physical, and also clarifying examples as non-relativistic operators that emerge when taking the non-relativistic breaking point of standard four-fermion operators. It moreover takes out the requirement for installing the field operators in full portrayals of the Lorentz gathering, and in this way gives a brought together depiction of every single conceivable turn for the dark issue molecule. This effective field theory is fundamentally for connections between dull issue and nucleons. To reach analyze, one requires the network components of these operators between nuclear cores. This marriage of a effective theory treatment of DM interactions with a treatment of the nuclear reaction demonstrates that there are six autonomous nuclear reaction capacities describing DM

versatile collaborations with cores, and that these reaction capacities are related with six single-molecule operators having the essential change properties under equality and time inversion [14].

The new reaction capacities are related with the nuclear convection present and related turn speed streams that depend unequivocally on nuclear compositeness. What's more, two impedance terms emerge, including extra many-sided quality. Such many-sided quality is useful, giving more demonstrative handles to experimentalist to abuse, as they try to decide the idea of DM. Our powerful theory of DM connections that incorporate CP protecting trades of turn 1 or less uses five of the six conceivable reactions [15].

Administrator framework components were assessed in a consonant oscillator premise, a decision that enables one to express the required shape factors as polynomials in the square of the three-energy exchange. The outcomes demonstrate an extensive variety of sensitivities to basic effective theory interactions, exceptionally subject to the decision of nuclear target. In a subsequent paper, we will break down test imperatives on the full viable theory utilizing these frame factors, however as more precise shape factors for heavier components wind up accessible in the writing, such investigations ought to end up progressively solid. Beside the change of nuclear shape factors, the outcomes here can be proceeded in a few headings. Models with inelastically-diffusing dark issue can be very much persuaded and prompt subjectively fascinating expectations, and it is helpful to stretch out the powerful theory examination to incorporate such operators and any extra conceivable nuclear reactions. Additionally, while a few blends of the operators here emerge effectively from UV models, for others, it is more subtle regardless of whether tuning is required. It is intriguing to see better if normal models for the full successful theory can be developed or not [16].

CONCLUSION

In this paper, the creator has considered a powerful theory to think about signs from DM coordinate recognition tests. Diverse operators in the NR theory compare to various kinds of connections amongst DM and SM quarks. They prompt subjectively unique force spectra. In this way if DM is found sooner rather than later DM coordinate identification, the force range will oblige the NR powerful theory and its conceivable field theory culminations. Important data on the idea of DM– core interactions can be acquired. There are as yet numerous subtle elements that should be concentrated to advance our comprehension of conceivable DM signals. For example, both the nuclear frame factor and the DM speed circulation could adjust the backlash range and spread the distinctions from DM elements. An entire rundown of the coordinating between quark or gluon operators and nucleon operators and the nuclear frame factors is as yet missing in the writing. Another issue originates from the DM speed circulation. At long last, the collaboration that triggers motions in DM coordinate identification may leave engraves in hadron colliders like the Tevatron and LHC. The successful theory contrasts for these two kinds of examinations due to the diverse kinematic administrations that they test. All things considered, for specific interactions, there may exist solid connections between's the immediate discovery and collider signals. At that point it will be exceedingly attractive to concentrate and look at data on DM elements from the two classes of tests.

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