# Wavelength-Independent Extinction in the Milky Way, Is it new physics?

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## Abstract

The paper Baruch (2025a) shows that there is an apparent wavelength-independent extinction coefficient of 0.06 magnitudes per kiloparsec across the Milky Way. Baruch 2025b) shows that the Hubble constant values of Riess et al (2016, 2018a and 2018b), Freedman et al (2019) and the Planck satellite (Ade et al 2014) coincide if the extinction coefficient is a function of the density of dark matter. This wavelength-independent extinction has a frequency threshold between 160Ghz and 300 Thz. This paper seeks a possible process by which dark matter can absorb light.The current data on dark matter is reviewed to determine how dark matter could act as a wavelength-independent absorber of light in the visible frequencies. The discussion of the role of inertia and momentum in general relativity and its relationship with the other forces since the Einstein paper on General Relativity of 1915 is reviewed. It is conjectured that for a pair of gravitationally bound dark matter particles a photon with sufficient momentum would effectively "ionise" the pair, releasing the two dark matter particles, and absorbing the photon. The approximate mass of the dark matter particle is derived. It is suggested that this dark matter extinction provides real data to help settle the role of inertia and momentum in General Relativity. A test for the "ionisation" process is suggested.

## Full Text

## Preamble

### Wavelength-Independent Extinction in the Milky Way: Is It New Physics?

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## Abstract

Baruch (2025a) demonstrates the existence of an apparent wavelength-independent extinction coefficient of 0.06 magnitudes per kiloparsec across the Milky Way. Baruch (2025b) further shows that the Hubble constant values reported by Riess et al. (2016, 2018a, 2018b), Freedman et al. (2019), and the Planck satellite (Ade et al. 2014) become consistent if this extinction coefficient is a function of dark matter density. This wavelength-independent extinction exhibits a frequency threshold between 160 GHz and 300 THz. The present paper investigates a possible mechanism by which dark matter could absorb light.

We review current data on dark matter to determine how it might act as a wavelength-independent absorber at visible frequencies. The discussion examines the role of inertia and momentum in general relativity and their relationship with other forces since Einstein' s 1915 paper on General Relativity. We conjecture that a photon with sufficient momentum could effectively "ionize" a gravitationally bound pair of dark matter particles, releasing the two particles while absorbing the photon. From this, we derive an approximate mass for the dark matter particle and suggest that this dark matter extinction provides real data to help resolve the role of inertia and momentum in General Relativity. A test for this "ionization" process is proposed.

**Key Words:** Stars -Distances; Stars -Variables -Cepheids; Galaxy -General; Cosmology -Dark Matter; Cosmology -Observations; Gravitation.

## 1. Introduction

In studying the photometric and parallax measurements of Milky Way Cepheids from Riess et al. (2021), Baruch (2025a) demonstrated that the unique combination of HST and Gaia data from the SHoES team can be used to separate the effects of extinction from the parallax zero-point offset. The SHoES team took great care to account for wavelength-dependent extinction, implying that any additional extinction would be wavelength-independent. Gaia parallaxes are now widely regarded as accurate to within one or two microarcseconds (Riess et al. 2022), though Riess has not examined the implications of this for the superior Cepheid data in Riess et al. (2021). Baruch (2025a) showed that extinction makes the Milky Way Cepheids in Riess et al. (2021) appear more distant and derived an absolute magnitude that resolves the Hubble tension.

Riess continued to use the uncorrected absolute magnitude, causing the Cepheids in local supernova galaxies—which suffer no intergalactic extinction—

to appear nearer. This constitutes the first step in the SHoES team distance ladder and drives the Riess et al. Hubble constant value above the Cosmic Microwave Background value from the Planck satellite (Ade et al. 2014). Using the SHoES Cepheid data from Riess et al. (2021) and the Carnegie-Chicago data from Freedman et al. (2019), Baruch (2025b) demonstrated that if wavelength-independent extinction of visible light in the Milky Way, Large Magellanic Cloud, and intergalactic space correlates with local dark matter density, the Hubble tension is eliminated.

In Sections 2 and 3, we argue that Gravitationally Interacting Massive Particles (GIMPs) represent the best candidate for dark matter. We propose that wavelength-independent photon absorption may occur via a momentum channel. Section 4 outlines the challenges of linking inertia and momentum to General Relativity and argues for experimental data to guide theoretical development. Section 5 examines photon momentum and its equivalent mass as the mechanism for interaction with dark matter above a quantum mechanical threshold, yielding a dark matter particle mass. Sections 6 and 7 consider the equation of state for dark matter binaries, and Section 8 predicts how the apparent Hubble constant will change at high redshift values.

## 2.0 Dark Matter

The standard ΛCDM model explains dark matter generation and predicts the mass of weakly interacting cold dark matter particles. However, projected masses for these particles span an enormous range, from a few keV (Vega et al. 2013) to 100 GeV and beyond (Bertone 2010; STFC 2020). Supersymmetric extensions to the standard ΛCDM model predict a Weakly Interacting Massive Particle (WIMP) in the TeV range, which has been the primary focus of particle searches. Large-scale detectors including the LUX experiment (Fox et al. 2014), the XMASS detector (Abe et al. 2018), and the CERN Large Hadron Collider (Craig 2013) have all returned null results, severely diminishing the probability that dark matter consists of WIMPs. Comprehensive searches for particles with masses from 20 GeV to 1 TeV are detailed by Tanabashi et al. (2018). Currently funded approaches to cold dark matter detection continue to assume WIMPs, despite little evidence supporting this paradigm (see the UK national review, STFC 2020).

The search for WIMPs has so far produced no signals whatsoever (Lai et al. 2023). Gibney (2020) describes the "Last Chance for WIMPs," focusing on XENON1T and DARWIN detectors that will eventually reach the neutrino floor where neutrino signals will overwhelm any potential dark matter detection.

## 2.1 Dark Matter That Only Interacts Through Gravity

Significant theoretical and experimental work has considered particles that interact exclusively through gravity: Gravitationally Interacting Massive Particles (GIMPs). Einstein (1919), shortly after publishing his General Relativity paper, suggested that gravity could play a significant role in elementary particle composition. Chung et al. (2001) and Kolb et al. (1998) proposed massive "Wimpzilla" particles in the mass range $10^{21}$ eV to $10^{25}$ eV, originally suggesting they would couple to both gravity and the weak nuclear force, with a preferred mass of $10^{23}$ eV.

More recent work by Fedderke et al. (2015), Chung et al. (2019), Li et al. (2019), and Kolb et al. (2019) has examined gravitational particle production at the end of inflation through Higgs portal operators. Kolb noted that "Perhaps the most elegant of these mechanisms is the gravitational production of WIMPzillas during, or at the end of, inflation," proposed by Chung et al. (1999) and Kuzmin (1999). He declared that "This scenario only requires the WIMPzilla to couple to gravity; specifically, there need not be any direct coupling with the Standard Model fields or the inflaton," coining the term GIMP. Li et al. (2019) also reviewed gravitational production of superheavy dark matter.

Additional theoretical work by Haro (2019a, 2019b), Hashiba (2019), and Ema (2018) suggests that dark matter abundance could be explained through GIMP production that interacts only gravitationally. Kleinert (2016) similarly proposed that elementary GIMP particles constitute the dark matter in the Universe.

On the experimental side, Carney et al. (2020) and Kawasaki (2019) have proposed direct gravitational detection of dark matter using quantum-limited mechanical precision displacement impulse sensors. These would detect the correlated gravitational force from a passing dark matter particle, based on the clear observational evidence that dark matter responds only to gravity. This work therefore focuses on GIMPs rather than WIMPs as the potential primary component of dark matter in the local universe.

## 3.0 Photon Gravitational Interactions

Photons possess an equivalent energy-related mass given by $m = h\nu/c^2$, where $m$ is the equivalent photon mass, $h$ is Planck' s constant, $c$ is the speed of light, and $\nu$ is the photon frequency. For a 0.5 micron wavelength photon in the blue part of the spectrum, this equivalent mass for gravitational interactions is about 2.46 eV or approximately $2 \times 10^{-36}$ kg. Photons also carry momentum. Photon gravitational interactions include stellar displacement observed by Eddington in 1919 (Dyson et al. 1920) and Einstein rings modeled by Bannikova (2014). Photon momentum also changes with gravitational redshift (Popper 1954). Our objective is to identify possible interaction mechanisms with dark matter.

## 4.0 General Relativity

It is widely accepted that Mach's view of momentum and inertia in his book *The Science of Mechanics* (1883 German, 1893 English) inspired Einstein to develop General Relativity, though they never agreed on the detailed inclusion of momentum and inertia in the theory. General Relativity provides an enormously successful description of space and time, built upon a small set of critical experimental data beginning with the precession of Mercury’ s perihelion—a problem that General Relativity solved. The theory predicted light bending by gravitational fields, dramatically confirmed by Arthur Eddington during the 1919 solar eclipse. The predicted gravitational redshift of light has been convincingly confirmed by Popper (1954) and many others since. Peale et al. (1979) linked energy and momentum within General Relativity to explain energy transfer in tidal friction processes affecting Io, Jupiter’ s moon. More recently, light bending has been further confirmed by numerous images of Einstein rings from large ground-based and space telescopes. A fundamental prediction of General Relativity—gravitational waves—has been dramatically confirmed by Abbott et al. (2016) using three different detectors. All this data forcefully confirms General Relativity, yet the role of momentum and inertia remains controversial and requires experimental results that directly link momentum with the gravitational field.

## 4.1 Inertia and Momentum in General Relativity

Dennis Sciama noted in 1953 that “As Einstein (1915) has pointed out, general relativity does not account satisfactorily for the inertial properties of matter, so that an adequate theory of inertia is still lacking.” Sciama renewed the search for the origin of inertia in light of General Relativity. A surprising result of his work was the prediction that far more matter exists in the universe than telescopes could observe—a precursor to observational evidence for dark matter. Sciama was followed throughout the latter 20th century by numerous attempts to integrate momentum and inertia into General Relativity or explain them: Moon and Spencer (1959), Burniston-Brown (1963), Feynman (1985), Bak et al. (1994), Graneau (2003), Gisin (2016), and Moradpour et al. (2019). The status of inertia and momentum in General Relativity is unique in that no experimental results currently link inertia or momentum directly to General Relativity. Hawking (1974) predicted that black holes, particularly their event horizons, would exhibit temperature and emit electromagnetic radiation, though no evidence yet supports this conjecture. Perhaps dark matter’ s wavelength-independent extinction of visible light will provide the necessary experimental data to link inertia and momentum with gravity and General Relativity, since the GIMP dark matter considered here interacts only gravitationally.

## 5.0 The Interaction of Visible Waveband Photons with Dark Matter

The author is aware of only two possible routes for photons to interact gravitationally with dark matter. First, consider scattering. While large gravitational fields completely described by General Relativity and spacetime curvature clearly alter photon directions, whether individual dark matter particles can do so is an entirely different question. Two problems arise: scattering would blur images of distant objects and would not exhibit a threshold effect. Considering these issues, we dismiss scattering as the cause of wavelength-independent dark matter extinction and seek an alternative mechanism.

We expect massive GIMP particles to obey quantum mechanical laws as fermions. Kolb (2019) and others, including Chung (2019), suggested GIMP particles would be fermions with half-integer spin. This paper assumes dark matter GIMP particles have spin one-half. When Bohr (1913) first discussed the hydrogen atom with its spin-half electron and proton, he sought to explain emission lines as a momentum problem, with photon momentum interacting with the angular momentum of the orbiting electron. We adopt Bohr' s initial momentum-centered approach here. The author is unaware of any commentators on inertia and momentum who would exclude momentum exchange between a photon and the angular momentum of a gravitationally bound pair of particles obeying quantum mechanics.

A century of discussion on inertia and momentum in General Relativity has reached no consensus. Strong evidence from Baruch (2025b) indicates that dark matter possesses an absorption coefficient for visible light, and in the absence of alternative conjectures, we take this approach seriously: the momentum of a photon can be absorbed by the angular momentum of a gravitationally bound pair of dark matter particles.

We conjecture that gravitational interaction enables dark matter particles to form quantum-mechanical binaries. A photon with momentum exceeding a specific threshold—below the momentum of visible light photons—would "ionize" such a pair, leaving the two particles unbound while absorbing the photon. With these assumptions, and knowing that millimeter-wave photons from the 160 GHz Cosmic Microwave Background lack sufficient energy to attenuate dark matter, we can calculate the dark matter particle mass.

Photons below 160 GHz (millimeter waves) would have insufficient energy to disrupt these binary particles. Since the maximum possible photon momentum threshold must be less than that of visible light photons (say, with wavelength about 1 micron), the dark matter particle mass can be calculated (see Appendix A for mathematical derivation).

For a 1 mm wavelength (300 GHz) photon:
$M = 2.40 \times 10^{-14}$ kg $\sim 1.35 \times 10^{13}$ GeV $= 1.35 \times 10^{22}$ eV

For a 1 micron wavelength (300 THz) photon:
$M = 9.55 \times 10^{-14}$ kg $\sim 5.36 \times 10^{13}$ GeV $= 5.36 \times 10^{22}$ eV

The binary size is given by the orbital radius $r$ when the energy threshold is reached:
For 1 micron: $r = 0.765 \times 10^{-18}$ m
For 1 mm: $r = 0.483 \times 10^{-16}$ m

These values follow Bohr' s (1913) hydrogen atom approach, but with gravity as the binding force. While not exact, the Bohr approximation is adequate. We envision two dark matter particles of approximate mass $2 \times 10^{13}$ GeV, obeying quantum mechanics and attracted only by gravity, forming binary pairs.

We conjecture these binary pairs possess a cross-section for photons above a threshold energy. This interaction between gravitationally bound pairs and electromagnetic quanta will further constrain General Relativity regarding inertia and momentum. Under normal interstellar conditions, these binaries should be stable and long-lasting.

## 6.0 Dark Matter in the Milky Way Galaxy

We assume the Milky Way' s dark matter halo and that of the LMC are spherical, broadly confirmed by recent work from Palau and Miralda-Escudé (2019). This has important implications for dark matter particles. The halo must have formed concurrently with the Milky Way galaxy and its stars, sharing similar angular momentum aligned with the galactic disk.

For the halo to remain roughly spherical over the galaxy's 13-billion-year lifespan, dark matter particles must orbit without energy loss. They must traverse stars and planets without significant energy dissipation, with the only modification being capture by massive black holes at the galactic center or stellar-mass black holes. Gravitational interactions with stars, planets, and gas clouds will chaotically alter galactic orbits, but particles will pass through millions of stars and planets without substantial energy loss, maintaining the spherical dark matter halo.

It is generally accepted that dark matter motion mirrors stellar motion, with only slight reflection of the galactic disk and sustained density throughout a spherical halo. The Gaia satellite (Katz et al. 2022) produced detailed maps of stellar motions relative to the Sun, extending Bovy' s (2017) Hipparcos-based work to stars with parallaxes greater than 10 milliarcseconds (within 100 parsecs). The average relative velocity of local stars peaks around 20 km/s. Dark matter relative velocity is generally expected to reflect this local stellar velocity.

## 6.1 The Formation of Dark Matter Binaries

We examine how dark matter particles might form binaries. The local stellar density is about 0.1 stars per cubic parsec (Bovy 2017; Widmark 2022), so a star sweeps out a cylinder of roughly 1 parsec radius. The dark matter density in the solar neighborhood is approximately $0.7 \times 10^{-21}$ kg m$^{-3}$.

Consider a hemispherical shell of radius 1 parsec and thickness 1 meter. Dark matter escaping this shell is replaced by incoming particles. This shell contains about $4 \times 10^{12}$ kg of dark matter, or for particles of mass $2 \times 10^{-14}$ kg ($10^{22}$ eV), about $2 \times 10^{26}$ particles. The shell is gravitationally attracted to the Sun and, with small relative velocity, becomes accreted.

Particles traverse the Sun in about 2000 seconds at approximately 650 km/s (the solar escape velocity). The density inside the Sun is about $10^{16}$ times greater than in interstellar space, reducing the average interparticle distance to about 1 mm—$10^5$ times smaller than in interstellar space. For these 2000 seconds, mutual gravitational attraction accelerates particles toward their collective center of mass. Upon exiting the Sun, they retain both their chaotic relative motion (~20 km/s) and the velocity toward their center of mass gained during transit. This additional velocity brings them close enough to feel other GIMPs' gravitational pull, enabling binary formation in subsequent millennia. This process occurs continuously with every star and planet.

Dynamical friction studies from Tremaine and Weinberg (1984) and more recent work by Szolgyen and Kocsis (2018) and Ginat and Panamarev et al. (2022)—initially concerning interactions of massive objects like galactic bars or globular clusters with stellar systems, and later multiple massive black holes—are relevant. For dark matter, stars moving through the galactic halo with impact radii of order 1 parsec will tend to concentrate dark matter in their turbulent wakes. Modeling this process remains work in progress.

## 7.0 The Interaction of Dark Matter with Normal Matter

Extending the mass calculations shows that Cosmic Microwave Background (CMB) radiation ensures these binary particles exist only in their ground state for the considered masses; clusters larger than pairs are unstable. Similar analysis indicates photons with frequencies $> 100$ MHz would disrupt the gravitational bond with a proton (radius $10^{-15}$ m). With such a low threshold and the universal presence of CMB radiation, these massive particles cannot remain bound to normal matter and exist only as single particles or ground-state binaries.

## 8.0 A Predictive Test

In the distant universe at higher redshifts ($z < 1000$), the CMB frequency exceeds 160 GHz. As $z$ increases, it reaches a threshold where the CMB prevents dark matter binary formation and "ionizes" any existing pairs, eliminating dark matter' s ability to absorb other electromagnetic radiation. At these distances, supernovae will appear brighter, and the universe' s expansion rate will again appear to accelerate. Supernova searches have so far been limited to $z < 2.3$ (Gupta 2023). We predict that for $z > 2.3$, the expansion rate derived from SN1a supernovae or other visible-wavelength standard candles will appear to increase. The James Webb Space Telescope may detect this apparent acceleration at high redshift.

## 9.0 Conclusions

This paper has sought a mechanism by which dark matter could absorb light. Baruch (2025a) shows a wavelength-independent extinction coefficient of 0.06 magnitudes per kiloparsec across the Milky Way. Extinction in the Milky Way, Large Magellanic Cloud, and intergalactic space explains both the Hubble tension and the recent apparent increase in the universe' s expansion rate. The extinction depends on dark matter density with a frequency threshold between 160 GHz and 300 THz.

We reviewed recent and planned dark matter searches, concluding that the key unexplored parameter space is Gravitationally Interacting Massive Particles (GIMPs) with masses $10^{22}$ eV $< M < 10^{25}$ eV. We considered photon equivalent mass and numerous theoretical efforts linking inertia and momentum to General Relativity. We conjecture that GIMPs can form binaries "ionizable" by photons above a threshold frequency, yielding a dark matter particle mass and providing experimental input for incorporating inertia and momentum into General Relativity. We showed that GIMP passage through stars supports binary formation and predict that beyond $z \approx 2.3$, the apparent expansion rate measured from distant supernovae will increase as CMB radiation destroys GIMP binaries, removing wavelength-independent extinction in intergalactic space.

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## Data Availability

No new data were generated or analyzed in support of this research.

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## Appendix A

To calculate the mass of the dark matter GIMP, we consider two dark matter GIMP particles gravitationally bound in a binary system, orbiting each other in the lowest energy state of circular orbits where quantum mechanics applies.

The gravitational force is balanced by radial acceleration. From Newton’ s law:

$$F = \frac{GM_{1M}2}{4r^2} \quad (1)$$

where $G = 6.67 \times 10^{-11}$ N m$^2$ kg$^{-2}$ is the gravitational constant, $M_1$ and $M_2$ are the particle masses (identical: $M$), and $r$ is the orbital radius. Thus:

$$F = \frac{GM^2}{4r^2} \quad (2)$$

For a particle in circular orbit, the centripetal acceleration is:

$$a = \frac{v^2}{r} \quad (3)$$

where $v$ is orbital velocity. The required force is:

$$F = Ma \quad (4)$$

giving:

$$F = \frac{Mv^2}{r} \quad (5)$$

Assuming quantized angular momentum analogous to the hydrogen atom (Bohr 1913):

$$\frac{nh}{2\pi} = Mrv \quad (6)$$

where $h = 6.63 \times 10^{-34}$ m$^2$ kg s$^{-1}$ and $\hbar = h/2\pi$. For the ground state ($n = 1$):

$$\hbar = Mrv \quad (7)$$

We assume photons above a threshold energy are absorbed by the binary, terminating its bound state and leaving two separate particles while absorbing the photon. The photon’ s momentum neutralizes the binary’ s momentum.

The photon momentum is $Mc$ and its energy is $Mc^2$, where $M$ is the equivalent mass defined by $M = h\nu/c^2$. The bound state energy is the integral of the binding force from infinity to $r$: $GM^2/4r$. However, it is the momentum that is neutralized, so the disruptive photon’ s momentum is $h/\lambda$.

The threshold momentum to disrupt the binary is:

$$\frac{GM^2}{4rc} = \frac{h}{\lambda} \quad (8)$$

From (2) and (5):

$$\frac{GM^2}{4r^2} = \frac{Mv^2}{r} \implies r = \frac{GM}{4v^2} \quad (9)$$

$$r = \frac{GM^2\lambda}{4ch} \quad (9i)$$

From (9) and (7) for a disruptive photon:

$$r = \frac{4\hbar^2}{GM^3} \quad (10)$$

Substituting $r$ from (8):

$$\frac{GM^2\lambda}{4hc} = \frac{4\hbar^2}{GM^3}$$

Solving for $M$:

$$M^5 = \frac{16\hbar^{3c} \cdot 2\pi}{G^2\lambda} = \frac{32\hbar^3\pi\nu}{G^2} \quad (11)$$

For a 1 mm wavelength photon ($\nu = 3 \times 10^{11}$ Hz):
$M^5 = 79 \times 10^{-70}$ kg, giving:
$M = 2.399 \times 10^{-14}$ kg $\sim 1.35 \times 10^{13}$ GeV $= 1.35 \times 10^{22}$ eV

For a 1 micron wavelength photon ($\nu = 3 \times 10^{14}$ Hz):
$M = 9.55 \times 10^{-14}$ kg $\sim 5.36 \times 10^{13}$ GeV $= 5.36 \times 10^{22}$ eV

The binary size is found by solving for $r$ using (9i) or (10):

For a 1 micron photon threshold: $r = 0.765 \times 10^{-8}$ Å $= 0.765 \times 10^{-18}$ m

For a 160 GHz (1.875 mm) photon threshold: $r = 1.07 \times 10^{-6}$ Å $= 1.07 \times 10^{-16}$ m

These calculations show that CMB radiation ensures binary particles exist only in their ground state for the considered masses; clusters larger than pairs are unstable. Similar analysis indicates photons with frequencies > 100 MHz would disrupt the gravitational bond with a proton (radius $10^{-15}$ m). With such a low threshold and the universal CMB presence, these massive particles cannot remain bound to normal matter and exist only as single particles or ground-state binaries.

*Note: Figure translations are in progress. See original paper for figures.*

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