Updated on 2023.05.05

neutrino (9)

2023-05-04, **Dark matter from sterile-sterile neutrino mixing**, Pasquale Di Bari et.al., 2305.03032v1

A solution to the problem of the origin of matter in the universe can be reasonably searched within extensions of the standard model that also explain neutrino masses and mixing. Models embedding the minimal seesaw mechanism can explain the observed matter-antimatter asymmetry of the universe via leptogenesis and dark matter via active-sterile neutrino mixing. In this case a keV lightest seesaw neutrino would play the role of warm dark matter particle. This traditional solution is now constrained by various cosmological observations. I will discuss the possibility that a much heavier but yet metastable (dark) right-handed neutrino with mass in the $1,{\rm TeV}$--$1 , {\rm PeV}$ range can play the role of (cold) dark matter particle. The right abundance would be produced by the Higgs induced mixing with a seesaw right-handed neutrino (RHINO model), i.e., by sterile-sterile neutrino mixing. Such a mixing would necessarily require a further extension of the minimal seesaw mechanism and can be described by a dimension-five effective operator. The same mixing would also necessarily induce dark neutrino instability with lifetimes that can be much longer than the age of the universe and can escape current constraints from neutrino telescopes. On the other hand, a contribution to very high energy neutrino flux produced by dark neutrino decays could explain an anomalous excess at 100 TeV energies confirmed recently by the IceCube collaboration. I will also discuss a simple UV completion where the mediator is given by a massive fermion. Intriguingly, it comes out that the favoured scale of new physics for RHINO to satisfy the dark matter requirements coincides with the grand-unified scale: a RHINO miracle.

2023-05-04, **Untying the growth index to relief the $σ_8$ discomfort**, Ziad Sakr et.al., 2305.02863v1

The fluctuation of matter parameter σ_8 is by model construction degenerate with the growth index γ. Here we try to study the effect on the cosmological parameters constraints from treating each independently by considering σ_8 as a free and not derived parameter along with γ, to then try to constrain all by three probes, namely the CMB spectrum, the growth measurements from redshift space distortions $f\sigma_8$ and the galaxy cluster counts. We also want to asses the impact of this relaxation on the σ_8 tension. We also propose a more sophisticated correction, along with the classical one that takes into account the impact of cosmology on the growth measurements, which is to adjust the growth to keep the observed power spectrum invariant with the background evolution. We found that untying the two parameters does not shift the maximum likelihood on either σ_8 or γ but rather allow for larger bounds with respect to when σ_8 is a derived parameter. More precisely, we obtain $\sigma_8 = 0.809\pm 0.043 $ and $\gamma = 0.613\pm 0.046$ in agreement with Planck constraints for the former and compatible with ΛCDM for the latter but with bounds enough wide to accomodate both values subject of tensions for σ_8. On the other hand, considering a tier correction yields $\sigma_8 = 0.734\pm 0.013$ close to the local values albeit with a growth index $\gamma = 0.636\pm 0.022$ while allowing a massive neutrinos yielded $\sigma_8 = 0.756\pm 0.024$, still preferring low values but with looser constraints, with $\gamma = 0.549\pm 0.048$ and a slight preference for $\Sigma m_\nu \sim 0.19$ value. We conclude that untying σ_8 and γ helps in relieving the discomfort on the former between CMB and local probes and that careful analyse should be followed when using data obtained in a model dependent way.(abridged)

2023-05-04, **Two-component vector WIMP, fermion FIMP dark matter model with an extended seesaw mechanism**, Francesco Costa et.al., 2305.02851v1

The document discusses a proposed extension to the Standard Model that aims to explain the presence of neutrino masses and the existence of dark matter. The model includes two potential candidates for dark matter, a vector WIMP and a fermion FIMP, and their combined presence accounts for the total amount of observed dark matter. This study examines the various ways in which dark matter could be produced within this model and explores the connections between the dark matter and neutrino sectors. It also examines various constraints from existing and future experiments. Additionally, the model includes a scalar field that can play a role in a first-order phase transition in the early universe, and the article looks at the potential for the production of gravitational waves as a result of this phase transition and their detectability. This study also assesses the possibility for this phase transition to be strong enough to drive the electroweak baryogenesis.

2023-05-03, **Bimodal black-hole mass distribution and chirp masses of binary black-hole mergers**, Fabian R. N. Schneider et.al., 2305.02380v1

In binary black-hole mergers from isolated binary-star evolution, both black holes are from progenitor stars that have lost their hydrogen-rich envelopes by binary mass transfer. Envelope stripping is known to affect the pre-supernova core structures of such binary-stripped stars and thereby their final fates and compact remnant masses. In this paper, we show that binary-stripped stars give rise to a bimodal black-hole mass spectrum with characteristic black-hole masses of about $9,\mathrm{M}_\odot$ and $16,\mathrm{M}_\odot$ across a large range of metallicities. The bimodality is linked to carbon and neon burning becoming neutrino-dominated, which results in interior structures that are difficult to explode and likely lead to black hole formation. The characteristic black-hole masses from binary-stripped stars have corresponding features in the chirp-mass distribution of binary black-hole mergers: peaks at about 8 and $14,\mathrm{M}_\odot$, and a dearth in between these masses. Current gravitational-wave observations of binary black-hole mergers show evidence for a gap at $10\text{--}12,\mathrm{M}_\odot$ and peaks at 8 and $14,\mathrm{M}_\odot$ in the chirp-mass distribution. These features are in agreement with our models of binary-stripped stars. In the future, they may be used to constrain the physics of late stellar evolution and supernova explosions, and may even help measure the cosmological expansion of the Universe.

2023-05-03, **Linear seesaw mechanism from dark sector**, A. E. Cárcamo Hernández et.al., 2305.02273v1

We propose a minimal model where a dark sector seeds neutrino mass generation radiatively within the linear seesaw mechanism. Neutrino masses are calculable, since tree-level contributions are forbidden by symmetry. They are also protected by lepton number symmetry, their smallness arising from small soft breaking terms. Lepton flavour violating processes e.g. $\mu \to e\gamma$ can be sizeable, despite the tiny neutrino masses. We comment also on dark-matter and collider implications.

2023-05-03, **Treating Detector Systematics via a Likelihood Free Inference Method**, Leander Fischer et.al., 2305.02257v1

Estimating the impact of systematic uncertainties in particle physics experiments is challenging, especially since the detector response is unknown analytically in most situations and needs to be estimated through Monte Carlo (MC) simulations. Typically, detector property variations are parameterized in ways that implicitly assume a specific physics model, which can introduce biases on quantities measured by an analysis. In this paper, we present a method to recover a model-independent, event-wise estimation of the detector response variation by applying a likelihood-free inference method to a set of MC simulations representing discrete detector realizations. The method

provides a re-weighting scheme for every event, which can be used to apply the effects of detector property variations fully decoupled from the assumed physics model. Using a toy MC example inspired by fixed-baseline neutrino oscillation experiments, we demonstrate the performance of our method. We show that our method fully decouples the modeling of the detector response from the physics parameters one wishes to measure in a MC forward-folding analysis.

2023-05-03, **A fast tunable driver of light source for the TRIDENT Pathfinder experiment**, Jiannan Tang et.al., 2305.01967v1

TRIDENT (The tROpIcal DEep-sea Neutrino Telescope) is a proposed next-generation neutrino telescope to be constructed in the South China Sea. In September 2021, the TRIDENT Pathfinder experiment (TRIDENT EXplorer, T-REX for short) was conducted to evaluate the in-situ optical properties of seawater. The T-REX experiment deployed three digital optical modules at a depth of 3420 meters, including a light emitter module (LEM) and two light receiver modules (LRMs) equipped with photomultiplier tubes (PMTs) and cameras to detect light signals. The LEM emits light in pulsing and steady modes. It features a fast tunable driver to activate light-emitting diodes (LEDs) that emit nanosecond-width light pulses with tunable intensity. The PMTs in the LRM receive single photo-electron (SPE) signals with an average photon number of approximately 0.3 per 1-microsecond time window, which is used to measure the arrival time distribution of the SPE signals. The fast tunable driver can be remotely controlled in real-time by the data acquisition system onboard the research vessel, allowing for convenient adjustments to the driver's parameters and facilitating the acquisition of high-quality experimental data. This paper describes the requirements, design scheme, and test results of the fast tunable driver, highlighting its successful implementation in the T-REX experiment and its potential for future deep-sea experiments.

2023-05-03, **Gravitational waves from a scotogenic two-loop neutrino mass model**, Cesar Bonilla et.al., 2305.01964v1

We propose a framework to account for neutrino masses at the two-loop level. This mechanism introduces new scalars and Majorana fermions to the Standard Model. It is assumed the existence of a global $\mathrm{U(1)\times \mathcal{Z}_2}$ symmetry which after partial breaking provides the stability of the dark matter candidates of the theory. The rich structure of the potential allows for the possibility of first-order phase transitions (FOPTs) in the early Universe which can lead to the generation of primordial gravitational waves as one of the potentially observable signatures of this model. Taking into account relevant constraints from lepton flavour violation, neutrino physics as well as the trilinear Higgs couplings at next-to-leading order accuracy, we have found a wide range of possible FOPTs which are strong enough to be probed at the proposed gravitational-wave interferometer experiments such as LISA.

2023-05-03, **Constraints on dark matter-neutrino scattering from the Milky-Way satellites and subhalo modeling for dark acoustic oscillations**, Kensuke Akita et.al., 2305.01913v1

The elastic scattering between dark matter (DM) and radiation can potentially explain small-scale observations that the cold dark matter faces as a challenge, as damping density fluctuations via dark acoustic oscillations in the early universe erases small-scale structure. We study a semi-analytical subhalo model for interacting dark matter with radiation, based on the extended Press-Schechter formalism and subhalos' tidal evolution prescription. We also test the elastic scattering between DM and neutrinos using observations of Milky-Way satellites from the Dark Energy Survey and PanSTARRS1. We conservatively impose strong constraints on the DM-neutrino scattering cross section of $\sigma_{{\rm DM}\text{-}\nu,n}\propto E_\nu^n$ $(n=0,2,4)$ at $95%$ confidence level (CL), $\sigma_{{\rm DM}\text{-}\nu,0}< 10^{-32}\ {\rm cm^2}\ (m_{\rm DM}/{\rm GeV})$, $\sigma_{{\rm DM}\text{-}\nu,2}< 10^{-43}\ {\rm cm^2}\ (m_{\rm DM}/{\rm GeV}) (E_\nu/E_{\nu}^0)^2$ and $\sigma_{{\rm DM}\text{-}\nu,4}< 10^{-54}\ {\rm cm^2}\ (m_{\rm

DM}/{\rm GeV})(E_\nu/E_{\nu}^0)^4$, where E_ν^0 is the average momentum of relic cosmic neutrinos today, $E_\nu^0 \simeq 3.15 T_\nu^0 \simeq 6.1\ {\rm K}$. By imposing a satellite forming condition, we obtain the strongest upper bounds on the DM-neutrino cross section at $95%$ CL, $\sigma_{{\rm DM}\text{-}\nu,0}< 4\times 10^{-34}\ {\rm cm^2}\ (m_{\rm DM}/{\rm GeV})$, $\sigma_{{\rm DM}\text{-}\nu,2}< 10^{-46}\ {\rm cm^2}\ (m_{\rm DM}/{\rm GeV})(E_\nu/E_{\nu}^0)^2$ and $\sigma_{{\rm DM}\text{-}\nu,4}< 7\times 10^{-59}\ {\rm cm^2}\ (m_{\rm DM}/{\rm GeV})(E_\nu/E_{\nu}^0)^4$.

dark matter (12)

2023-05-04, **Evidence for Large Scale, Rapid Gas Inflows in z~2 Star Forming Disks**, R. Genzel et.al., 2305.02959v1

We report high quality H${\alpha}$/CO, imaging spectroscopy of nine massive, disk galaxies on the star forming, Main Sequence (henceforth 'SFGs'), near the peak of cosmic galaxy evolution (z~~1.1-2.5), taken with the ESO-VLT, IRAM-NOEMA and ALMA. We fit the major axis position-velocity cuts with beam-convolved, forward-models with a bulge, a turbulent rotating disk, and a dark matter (DM) halo. We include priors for stellar and molecular gas masses, optical light effective radii and inclinations, and DM masses from our previous rotation curve analyses of these galaxies. We then subtract the inferred 2D model galaxy velocity and velocity dispersion maps from those of the observed galaxies. We investigate whether the residual velocity and velocity dispersion maps show indications for radial flows. We also carry out kinemetry, a model independent tool for detecting radial flows. We find that all nine galaxies exhibit significant non-tangential flows. In six SFG, the inflow velocities (v_r~~30-90 km s^{-1}, 10-30% of the rotational component) are along the minor axis of these galaxies. In two cases the inflow appears to be off the minor axis. The magnitudes of the radial motions are in broad agreement with the expectations from analytic models of gravitationally unstable, gas rich disks. Gravitational torques due to clump and bar formation, or spiral arms, drive gas rapidly inward and result in the formation of central disks and large bulges. If this interpretation is correct, our observations imply that gas is transported into the central regions on ~10 dynamical time scales.

2023-05-04, **The FLUKA cross sections for cosmic-ray leptons and uncertainties on current positron predictions**, Pedro De la Torre Luque et.al., 2305.02958v1

Cosmic-ray (CR) antiparticles have the potential to reveal signatures of unexpected astrophysical processes and even new physics beyond the Standard Model. Recent CR detectors have provided accurate measurements of the positron flux, revealing the so-called positron excess at high energies. However, the uncertainties related to the modelling of the local positron flux are still very high, significantly affecting our models of positron emission from pulsars and current dark matter searches. In this work, we report a new set of cross sections for positron and electron production derived from the {\tt FLUKA} code. We compare them with the most extended cross-section data-sets and show the impact of neglecting the positron production from heavy CRs. Then, we review the most significant sources of uncertainties in our current estimations of the secondary positron flux at Earth and examine for the first time the impact of considering the spiral arm structure of the Galaxy in these estimations. Finally, we provide state-of-the-art predictions of the local positron flux and discuss the limitations of our dark matter searches with positrons and difficulties to determine the contribution from pulsars to the positron flux at low energies.

2023-05-04, **Gravitational Lensing of Gravitational Waves: Probing Intermediate Mass Black Holes in Galaxy Lenses with Global Minima**, Ashish Kumar Meena et.al., 2305.02880v1

In this work, we study microlensing effects in strongly lensed gravitational wave (GW) signals corresponding to global minima in galaxy-scale lenses. We find that stellar microlenses alone are

unable to introduce noticeable wave effects in the global minima GW signals at strong lensing magnification $(\mu)<50$ with match value between unlensed and lensed GW signals being above ${\sim}99.5%$ in ${\sim}90%$ of systems. Since the stellar microlenses introduce negligible wave effects in global minima, they can be used to probe the intermediate-mass black hole (IMBH) lenses in the galaxy lens. We show that the presence of an IMBH lens with mass in the range $[50,10^3]~{\rm M_\odot}$ such that the global minima lies within five Einstein radius of it, the microlensing effects at $f<10^2$ Hz are mainly determined by the IMBH lens for $\mu<50$. Assuming that a typical strong lensing magnification of 3.8 and high enough signal-to-noise ratio (in the range $\sim[10, 30]$) to detect the microlensing effect in GW signals corresponding to global minima, with non-detection of microlensing effects in ${\sim}15 ({\sim}150)$ lensed GW signals, we can rule out dark matter fraction $>10% (>1%)$ made of IMBH population inside galaxy lenses in mass range $[50, 10^3] {\rm M_\odot}$ with ${\sim}$90% confidence.

2023-05-04, **Probing Dark Matter via Effective Field Theory Approach**, Ayşe Elçiboğa Kuday et.al., 2305.02592v1

We analyse dark matter in most general form of effective field theory approach. To examine the interactions between weakly interacting massive particles(WIMPs) and Standard Model (SM) particles, we use the six-dimensional EFT mediated by new physics scale Λ at tree level. After implementing a new effective field theory model in FeynRules \cite{Feynrules} We investigate the theory and constrain the theory by using relic density generated by MadDM\cite{Maddm} tool of MadGraph5_aMC@NLO \cite{mg5}.

2023-05-04, **Gravitational freeze-in dark matter from Higgs Preheating**, Ruopeng Zhang et.al., 2305.02568v1

Gravitational freeze-in is a mechanism to explain the observed dark matter relic density if dark matter neither couples to inflation nor to standard model sector. In this work, we study gravitational freeze-in dark matter production during Higgs preheating based on non-perturbative resonance. Using reliable lattice method to handle this non-perturbative process, we show that tachyonic resonance is prohibited by strong back reaction due to Higgs self interaction needed to keep the positivity of potential during preheating, and parameter resonance is viable by tuning the Higgs self-interaction coupling to be small enough in ultraviolet energy scale. We then derive the dark matter relic density under the context of Higgs preheating, and uncover a new dark matter parameter space with dark matter mass larger than inflaton mass, which arises from out-of-equilium Higgs annihilation. Finally, we briefly remark the open question of testing gravitational dark matter.

2023-05-03, **On the growth of supermassive black holes formed from the gravitational collapse of fermionic dark matter cores**, C. R. Argüelles et.al., 2305.02430v1

Observations support the idea that supermassive black holes (SMBHs) power the emission at the center of active galaxies. However, contrary to stellar-mass BHs, there is a poor understanding of their origin and physical formation channel. In this article, we propose a new process of SMBH formation in the early Universe that is not associated with baryonic matter (massive stars) or primordial cosmology. In this novel approach, SMBH seeds originate from the gravitational collapse of fermionic dense dark matter (DM) cores that arise at the center of DM halos as they form. We show that such a DM formation channel can occur before star formation, leading to heavier BH seeds than standard baryonic channels. The SMBH seeds subsequently grow by accretion. We compute the evolution of the mass and angular momentum of the BH using a geodesic general relativistic disk accretion model. We show that these SMBH seeds grow to $\sim 10^9$-$10^{10} M_\odot$ in the first Gyr of the lifetime of the Universe without invoking unrealistic (or fine-tuned) accretion rates.

2023-05-03, **Analysis of Direct and Indirect Detection of Fermionic Dark Matter of 6-Dimensional Effective Field Theory**, Ayşe Elçiboğa Kuday et.al., 2305.02302v1

We present an analysis of fermionic dark matter (DM) in the context of 6 dimensional Effective Field Theory (EFT). We also compared the result generated via the 6-dimensional EFT analysis with the current experimental results for dark matter searches. These experiments are methodically categorised as direct and indirect search and present some constraints on dark matter model parameters of 6-dimensional EFT. We constructed a new set of tools ensuring DM researches in various platforms. The model parameters are presented to guide DM production in colliders by taking account of the upper limits at direct and indirect searches. In this paper we apply our approach for fermionic case to test the verification of the method. There are various type of search methods for DM, each depends on type of interaction of dark matter with SM particles. Finally we analysed fermionic DM candidate of 6-dimensional Effective Field Theory (EFT) at the platforms of DM searches. A new set of numerical tools is specified for 6-dimensional fermionic DM model, and these tools are also tested.

2023-05-03, **Hydrodynamic effects on the filtered dark matter produced by a first-order phase transition**, Siyu Jiang et.al., 2305.02218v1

Motivated by current status of dark matter (DM) search, a new type of DM production mechanism is proposed based on the dynamical process of a strong first-order phase transition in the early universe, namely, the filtered DM mechanism. We study the hydrodynamic effects on the DM relic density. By detailed calculations, we demonstrate that the hydrodynamic modes with the corresponding hydrodynamic heating effects play essential roles in determining the DM relic density. The corresponding phase transition gravitational wave could help to probe this new mechanism.

2023-05-03, **Impacts of dark matter interaction on nuclear and neutron star matter within the relativistic mean-field model**, H. C. Das et.al., 2305.02065v1

This thesis explores the effects of dark matter (DM) on neutron stars (NSs) using the relativistic mean-field (RMF) model. The effects of DM on NS properties, including the mass-radius relation, the moment of inertia, and tidal deformability, are calculated by varying its fraction. The study found that the EOS becomes softer with increasing DM momentum, and the DM has marginal effects on nuclear matter properties, except for the EOSs and binding energy per particle. The study also calculated the properties of isolated, static, and rotating DM admixed NS and found that the DM has significant effects on both static and rotating NS. We have also observed that a tiny amount of DM can accumulate inside the NS, and more amount of it makes the NS unstable. The study also suggests that the secondary component might be a NS with DM content if the underlying nuclear EOS is sufficiently stiff. The f-mode oscillations of the DM admixed hyperon stars are calculated and found that there exist a correlation between canonical f-mode frequency and the dimensionless tidal deformability parameter ($\Lambda_{1.4}$) and we have put a constraint on f-mode frequency using GW170817 data. Finally, we have calculated the DM admixed binary NS properties and found that the binary system becomes less deformed and sustains more time in its inspiral phases with the addition of DM. Therefore, we suggest that one can take DM inside the compact objects while modeling the inspiral waveforms for the BNS systems.

2023-05-03, **On underestimation of the inelastic interactions in the direct dark matter search**, Vadim A. Bednyakov et.al., 2305.02050v1

In the paper expressions are obtained for the event rates expected in experiments aimed at direct detection of dark matter (DM) particles. These expressions allow one to estimate the rates taking into account simultaneously elastic (coherent) and inelastic (incoherent) channels of DM particle interaction with nuclei. The nonzero nuclear excitation energies are used in the calculation of the

inelastic scattering contributions. A strong correlation between the excitation energy and the recoil energy of the excited nucleus limits the possibility of the inelastic channel detection with a number of nuclei. Together with the standard model of the DM distribution in the Galaxy some models are considered, which allow higher speeds of the DM particle. As the nuclear recoil energy, TA, increases, the dominance of the elastic interaction channel is smoothly replaced by the dominance of the inelastic one. Therefore, if a detector is set up to detect only elastic scattering events, it starts to lose capability of seeing anything. The only way to notice the interaction remains the gamma radiation from the deexcitation of the nucleus. In the case of spin-independent DM interaction, as TA increases, the inelastic contribution quickly dominates. If the DM particle interacts only spin-dependently, the detectors focused on registration of the elastic spin-dependent DM signal will see nothing, since the signal goes through the inelastic channel. It looks like the desired DM interaction could have a noticeable intensity, but the DM detector is unable to detect it. Therefore, a setup aimed at the direct DM detection should register two signals. The first is the nuclear recoil energy and the second is the gamma-quanta with a certain energy from the target nucleus deexitation. The experiment will provide the complete information about the DM interaction.

2023-05-03, **The self-confinement of electrons and positrons from dark matter**, Marco Regis et.al., 2305.01999v1

Radiative emissions from electrons and positrons generated by dark matter (DM) annihilation or decay are one of the most investigated signals in indirect searches of WIMPs. Ideal targets must have large ratio of DM to baryonic matter. However, such ``dark'' systems have a poorly known level of magnetic turbulence, which determines the residence time of the electrons and positrons and therefore also the strength of the expected signal. This typically leads to significant uncertainties in the derived DM bounds. In a novel approach, we compute the self-confinement of the DM-induced electrons and positrons. Indeed, they themselves generate irregularities in the magnetic field, thus setting a lower limit on the presence of the magnetic turbulence. We specifically apply this approach to dwarf spheroidal galaxies. Finally, by comparing the expected synchrotron emission with radio data from the direction of the Draco galaxy collected at the Giant Metre Radio Telescope, we show that the proposed approach can be used to set robust and competitive bounds on WIMP DM.

2023-05-03, **Constraining the dark matter interpretation of the positron excess with $γ$-ray data**, Haoxiang Zhan et.al., 2305.01992v1

The particle origin of dark matter (DM) is still one of the main puzzles in modern physics. One of the most promising search strategy to detect DM at laboratories is through the indirect search of cosmic particles that are produced from DM annihilation in space. In particular, the flux of cosmic positrons has been measured with high precision by the AMS-02 experiment demonstrating that an excess above 10 GeV, with respect to the secondary production, is present. We study in this paper the possible DM origin of the positron excess finding the values of the DM mass M and annihilation cross section $\langle \sigma v \rangle$ that are needed to fit high-energy positron data. In particular, we find that for DM annihilating into $b\bar{b}$ it is required to have $M=43$ TeV and $\langle \sigma v \rangle = 10^{-21}$ cm^3/s while for $\tau^+\tau^-$ $M=2$ TeV and $\langle \sigma v \rangle = 3\times 10^{-23}$ cm^3/s. If DM produce positrons, they are expected to generate gamma rays from the center of the Milky Way and around dwarf galaxy satellites of the Galaxy. We thus combine the values for the DM mass and annihilation cross section obtained with the fit to AMS-02 positron data with the upper limits derived with the non-detection of γ rays with HESS in the direction of the Galactic center and Fermi-LAT for the combined analysis of dwarf galaxies. The main result of the paper is that only DM annihilating into $\mu^+ \mu^-$ with a mass around 500 GeV and $\langle \sigma v \rangle = 4\times 10^{-24}$ cm^3/s can fit AMS-02 data and be compatible with the upper limits found with γ rays. As for the $\tau^+ \tau^-$ ($b\bar{b}$) channel, DM can contribute at most at a few tens $%$ (a few %) level.

supernova (7)

2023-05-04, **SuperNOVA: Design Strategies and Opportunities for Interactive Visualization in Computational Notebooks**, Zijie J. Wang et.al., 2305.03039v1

Computational notebooks such as Jupyter Notebook have become data scientists' de facto programming environments. Many visualization researchers and practitioners have developed interactive visualization tools that support notebooks. However, little is known about the appropriate design of visual analytics (VA) tools in notebooks. To bridge this critical research gap, we investigate the design strategies in this space by analyzing 159 notebook VA tools and their users' feedback. Our analysis encompasses 62 systems from academic papers and 103 systems sourced from a pool of 55k notebooks containing interactive visualizations that we obtain via scraping 8.6 million notebooks on GitHub. We also examine findings from 15 user studies and user feedback in 379 GitHub issues. Through this work, we identify unique design opportunities and considerations for future notebook VA tools, such as using and manipulating multimodal data in notebooks as well as balancing the degree of visualization-notebook integration. Finally, we develop SuperNOVA, an open-source interactive tool to help researchers explore existing notebook VA tools and search for related work.

2023-05-04, **One matter density discrepancy to alleviate them all or further trouble for ΛCDM model**, Ziad Sakr et.al., 2305.02846v1

We investigate whether the two cosmological discrepancies on the Hubble constant (H_0) and the matter fluctuation parameter (σ_8) could be traded by only one on the present value of the matter density ($\Omega_{\rm{M}}$). We combined different probes in an agnostic approach by, either relaxing the calibration parameters in each probe in order to be set by the data, or by only including priors with the condition that they are obtained independently from the discrepant parameters. We also compiled and used a dataset from previous direct measurements of $\Omega_{\rm{M}}$. We found when combining, as our baseline, galaxy clusters counts + cluster baryon fraction probe + cosmic chronometers + direct $\Omega_{\rm{M}}$ + priors from BBN and CMB, that both parameters, H_0 and σ_8, are consistent with those inferred with local probes, with $\sigma_8 = 0.745 \pm 0.05$ while $H_0 = 73.8 \pm 3.01$, and that for a value of $\Omega_{\rm{M}} = 0.22 \pm 0.01$ at more than 3σ from that usually determined by CMB. We also found similar preferences when replacing cosmic chronometers (CC) by the Supernovae (SN) data while allowing its calibration parameter to vary. However discrepancies appeared when we combined SN in addition to CC suggesting either inconsistencies between the SN sample and the other probes used or a serious challenge to our hypothesis. We conclude that, either reconciling both tensions requires local inferred values of matter density at odd with those obtained by CMB, reviving by then an overlooked discrepancy, or simply that further evidences are indicating that ΛCDM model is facing more difficulties to accommodate simultaneously all the current available observations.(abridged)

2023-05-04, **Tracing Pop III supernovae with extreme energies through the Sculptor dwarf spheroidal galaxy**, Ása Skúladóttir et.al., 2305.02829v1

The Sculptor dwarf spheroidal galaxy is old and metal-poor, making it ideal to study the earliest chemical enrichment in the Local Group. We followed up the most metal-poor star known in this (or any external) galaxy, AS0039, with high-resolution ESO VLT/UVES spectra. Our new analysis confirmed its low metallicity, [Fe/H]=-3.90, and that it is extremely C-poor, with A(C)=+3.60, which corresponds to [C/Fe]=-0.33 (accounting for internal mixing). This adds to the evidence of Sculptor being intrinsically C-poor at low [Fe/H]. However, here we also report a new discovery of a carbon-enhanced metal-poor star in Sculptor, DR20080, with no enhancement of Ba (CEMP-no), indicative of enrichment

by zero-metallicity low-energy supernovae. This is the first evidence of a dual population of CEMP-no and C-normal stars in Sculptor at $\rm[Fe/H]\leq{-3}$. The fraction of CEMP-no stars is still low, $9^{+11}_{-8}%$ at $\rm -4\leq[Fe/H]\leq-3$, compared to the significantly higher fraction in the Milky Way halo, $\approx40%$. In addition, we re-derive chemical abundances of light, α-, iron peak, and neutron-capture elements in all Sculptor stars at $\rm [Fe/H]\leq-2.8$, with available high-resolution spectra. Our results show that at these low [Fe/H], Sculptor is deficient in light elements (e.g. C, Na, Al, Mg) relative to both the Milky Way halo, and ultra-faint dwarf galaxies, pointing towards significant contribution of high-energy supernovae. Furthermore, the abundance pattern of the star AS0039 is best fitted with a zero-metallicity hypernova progenitor, with a mass of $M=20$M$_\odot$. Our results in Sculptor, at $\rm[Fe/H]\leq-3$, therefore suggest significant enrichment by both very low-energy supernovae and hypernovae, solidifying this galaxy as one of the benchmarks for understanding the energy distribution of the first supernova in the Universe.

2023-05-03, **Carbon Stars as Standard Candles: An Empirical Test for the Reddening, Metallicity, and Age Sensitivity of the J-region Asymptotic Giant Branch (JAGB) Method**, Abigail J. Lee et.al., 2305.02453v1

The J-region Asymptotic Giant Branch (JAGB) method is a standard candle based on the intrinsic luminosities of carbon stars in the near infrared. For the first time, we directly constrain the impact of metallicity, age, and reddening on the JAGB method. We assess how the mode, skew, and scatter of the JAGB star luminosity function change throughout diverse stellar environments in M31's NE disk from 13<d<18 kpc using data from the Panchromatic Hubble Andromeda Treasury (PHAT). As expected, the mode is found to be fainter in higher-reddening regions. To cross-check this result, we also measure a fiducial J-band ground-based JAGB distance using data from the UKIRT/WFCam in M31's outermost disk (18<d<40 kpc) where internal reddening is minimal. We find that this J-band distance modulus agrees well with the F110W distance moduli measured in the lowest reddening regions of the PHAT data, demonstrating the JAGB method is most accurate if measured in the low-reddening outer disks of galaxies. On the other hand, the mode of the JAGB star luminosity function appears empirically to show no dependence on metallicity and age, disputing theoretical predictions that the average luminosity of metal-rich carbon stars is brighter than for metal-poor carbon stars. In conclusion, the JAGB method proves to be a robust standard candle capable of calibrating the luminosities of type Ia supernovae and therefore providing a high-accuracy, high-precision measurement of the Hubble constant.

2023-05-03, **Evidence of First Stars-enriched Gas in High-redshift Absorbers**, A. Saccardi et.al., 2305.02346v1

The first stars were born from chemically pristine gas. They were likely massive, and thus they rapidly exploded as supernovae, enriching the surrounding gas with the first heavy elements. In the Local Group, the chemical signatures of the first stellar population were identified among low-mass, long-lived, very metal-poor ([Fe/H]<-2) stars, characterized by high abundances of carbon over iron ([C/Fe]>+0.7): the so-called carbon-enhanced metal-poor stars. Conversely, a similar carbon excess caused by first-star pollution was not found in dense neutral gas traced by absorption systems at different cosmic time. Here we present the detection of 14 very metal-poor, optically thick absorbers at redshift z~3-4. Among these, 3 are carbon-enhanced and reveal an overabundance with respect to Fe of all the analyzed chemical elements (O, Mg, Al, and Si). Their relative abundances show a distribution with respect to [Fe/H] that is in very good agreement with those observed in nearby very metal-poor stars. All the tests we performed support the idea that these C-rich absorbers preserve the chemical yields of the first stars. Our new findings suggest that the first-star signatures can survive in optically thick but relatively diffuse absorbers, which are not sufficiently dense to sustain star formation and hence are not dominated by the chemical products of normal stars.

2023-05-03, **EMPRESS. XIII. Chemical Enrichments of Young Galaxies Near and Far at z ~ 0 and 4-10: Fe/O, Ar/O, S/O, and N/O Measurements with Chemical Evolution Model Comparisons**, Kuria Watanabe et.al., 2305.02078v1

We present gas-phase elemental abundance ratios of 7 local extremely metal-poor galaxies (EMPGs) including our new Keck/LRIS spectroscopy determinations together with 33 JWST $z\sim 4-10$ star-forming galaxies in the literature, and compare chemical evolution models. We develop chemical evolution models with the yields of core-collapse supernovae (CCSNe), Type Ia supernovae, hypernovae (HNe), and pair-instability supernovae (PISNe), and compare the EMPGs and high-z galaxies in conjunction with dust depletion contributions. We find that high Fe/O values of EMPGs can (cannot) be explained by PISN metal enrichments (CCSN/HN enrichments even with the mixing-and-fallback mechanism enhancing iron abundance), while that the observed Ar/O and S/O values are much smaller than the predictions of the PISN models. The abundance ratios of the EMPGs can be explained by the combination of Type Ia SNe and CCSNe/HNe whose inner layers of argon and sulfur mostly fallback, which are comparable with Sculptor stellar chemical abundance distribution, suggesting that early chemical enrichment is taken place in the EMPGs. Comparing our chemical evolution models with the star-forming galaxies at $z\sim 4-10$, we find that the Ar/O and S/O ratios of the high-z galaxies are comparable with those of the CCSNe/HNe models, while majority of the high-z galaxies do not have constraints good enough to rule out contributions from PISNe. The high N/O ratio recently reported in GN-z11 cannot be explained even by rotating PISNe, but could be reproduced by the winds of rotating Wolf Rayet stars that end up as a direct collapse.

2023-05-03, **Semi-Parametric Identification and Estimation of Interaction and Effect Modification in Mixed Exposures using Stochastic Interventions**, David B. McCoy et.al., 2305.01849v1

In many fields, including environmental epidemiology, researchers strive to understand the joint impact of a mixture of exposures. This involves analyzing a vector of exposures rather than a single exposure, with the most significant exposure sets being unknown. Examining every possible interaction or effect modification in a high-dimensional vector of candidates can be challenging or even impossible. To address this challenge, we propose a method for the automatic identification and estimation of exposure sets in a mixture with explanatory power, baseline covariates that modify the impact of an exposure and sets of exposures that have synergistic non-additive relationships. We define these parameters in a realistic nonparametric statistical model and use machine learning methods to identify variables sets and estimate nuisance parameters for our target parameters to avoid model misspecification. We establish a prespecified target parameter applied to variable sets when identified and use cross-validation to train efficient estimators employing targeted maximum likelihood estimation for our target parameter. Our approach applies a shift intervention targeting individual variable importance, interaction, and effect modification based on the data-adaptively determined sets of variables. Our methodology is implemented in the open-source SuperNOVA package in R. We demonstrate the utility of our method through simulations, showing that our estimator is efficient and asymptotically linear under conditions requiring fast convergence of certain regression functions. We apply our method to the National Institute of Environmental Health Science mixtures workshop data, revealing correct identification of antagonistic and agonistic interactions built into the data. Additionally, we investigate the association between exposure to persistent organic pollutants and longer leukocyte telomere length.