WG5 @ WHEPP XVI

Day	2:00-2:30 PM	2:30-3:30 PM	4:00-5:00 PM
December 1	Registration		
December 2	Subodh to make opening remarks about primordial black holes	Richa Arya, Sukannya Bhattacharya	Discussion
December 3	Discussion	Piyali Banerjee Ajit Srivastava	Discussion
December 4	Discussion		Discussion
December 5	Mohanty to make opening remarks about dark matter and axions	Aritra Gupta, Tarak Nath Maity,	Discussion
December 6	Discussion	Arvind Kumar Mishra, Dibyendu Nanda	Discussion
December 7	Discussion	Avik Paul, Pritam Sen	Colloquium by Prof. Rohini Godbole
December 8	Excursion		
December 9	Discussion	Devabrat Mahanta, Mostafizur Rahman	Discussion
December 10	Summary		

ON AXIONS AND DARK MATTER

Speaker: Aritra Gupta

Title: Dark matter capture in celestial objects: Improved treatment of multiple scattering and updated constraints from white dwarfs

Abstract: We revisit dark matter (DM)capture in celestial objects, including the impact of multiple scattering, and obtain updated constraints on the DM-proton cross-section using observations of white dwarfs. Considering a general form for the energy loss distribution in each scattering, we derive an exact formula for the capture probability through multiple scatterings. We estimate the maximum number of scatterings that can take place, in contrast to the number required to bring a dark matter particle to rest. We employ these results to compute a "dark" luminosity (LDM), arising solely from the thermalized annihilation products of the captured dark matter. Demanding that LDM does not exceed the luminosity of the white dwarfs in the M4 globular cluster, we set a bound on the DM-proton cross-section, almost independent of the dark matter mass between 100 GeV and 1 PeV and mildly weakening beyond. This is a stronger constraint than those obtained by direct detection experiments in both large masses (M>5 TeV) and small mass (M<10 GeV) regimes. For dark matter lighter than 350 MeV, which is beyond the sensitivity of present direct detection experiments, this is the strongest available constraint.

Speaker: Tarak Nath Maity, IIT Kharagpur

Title: Exchange driven freeze out of dark matter

Abstract: In this talk, we will introduce a novel mechanism where processes that preserve the number density of the dark sector set the relic density of a thermal particulate dark matter. In a relatively degenerate multipartite dark sector if there is a considerable time lapse between the freeze-out of various species then process like exchange between dark sector constituents can play the pivotal role of driving freeze out and setting dark matter relic density. As a proof of principle, we present simple scalar models with viable dark matter in the GeV scale to demonstrate this phenomenon.

Speaker: Arvind Kumar Mishra, PRL

Title: Viscous dark Matter cosmology

Abstract: Viscous dark matter (DM) has a rich physics and interesting consequences in contrast to the perfect DM fluid description. In our study, we consider the viscous Self-Interacting Dark Matter (SIDM) and show that its viscosity is strong enough to account for the present accelerated expansion of the Universe without requiring dark energy component. We find that the dissipative effects of the SIDM become prominent at the late time of cosmic evolution and can explain the low redshift observational data. Further, we also show that the viscous DM fluid dissipates energy and can generate photons in the low-frequency tail of Cosmic Microwave Background (CMB) radiation and may explain the reported EDGES anomaly in the 21-cm signal.

Speaker: Dibyendu Nanda, Indian Institute of Technology Guwahati

Title: Connecting Light Dirac Neutrinos to a Two-component Dark Matter Scenario

Abstract: We propose a new gauged B - L extension of the standard model where light neutrinos are of Dirac type, naturally acquiring sub-eV mass after electroweak symmetry breaking. This is realized by choosing a different B - L charge for right-handed neutrinos than the usual −1 so that the Dirac Yukawa coupling involves an additional neutrinophilic scalar doublet instead of the usual Higgs doublet. The model can be made anomaly free by considering four additional chiral fermions which give rise to two massive Dirac fermions by appropriate choice of singlet scalars. The choice of scalars not only helps in achieving the desired particle mass spectra via spontaneous symmetry breaking but also leaves a remnant Z_2 × Z_2^{\prime} symmetry to stabilize the two dark matter candidates. Apart from this interesting link between Dirac nature of light neutrinos and multi-component dark matter sector, we also find that the dark matter parameter space is constrained mostly by the cosmological upper limit on effective relativistic degrees of freedom Δ N_{eff} which gets enhanced in this model due to the thermalization of the light right-handed neutrinos by virtue of their sizeable B - L gauge interactions.

Speaker: Avik Paul, SINP, E-mail: avik.paul@saha.ac.in

Title: Neutron star cooling via axion emission by nucleon-nucleon axion bremsstrahlung

Abstract: Neutron stars generally cool off by the emission of gamma rays and neutrinos. But axions can also be produced inside a neutron star by the process of nucleon~Vnucleon axion bremsstrahlung. The escape of these axions adds to the cooling process of the neutron star. We explore the nature of cooling of neutron stars including the axion emission and compare our result with the scenario when the neutron star is cooled by only the emission of gamma rays and neutrinos. In our calculations we consider both the degenerate and non-degenerate limits for such axion energy loss rate and the resulting variation of luminosity with time and variation of surface temperature with time of the neutron star. In short, the thermal evolution of a neutron star is studied with three neutron star masses (1.0, 1.4 and 1.8 solar masses) and by including the effect of axion emission for different axion masses (m_{a}=10^{-5} eV, 10^{-3} eV and 10^{-2} eV) and compared with the same when the axion emission is not considered. We compared theoretical cooling curve with the observational data of three pulsars PSR B0656+14, Geminga and PSR B1055-52 and finally gave an upper bound on axion mass limits m_{a} ≤ 10^{-3} eV which implies that the axion decay constant f_{a} ≥ 0.6 \times10^{10} GeV.

Speaker: Pritam Sen, IMSc, Chennai

Title: Cancellation of infrared divergences in bino-like theories of dark matter at finite temperature

Abstract: Models incorporating moderately heavy dark matter (DM) typically need charged (scalar) fields to establish admissible relic densities. Since the DM freezes out at an early epoch, thermal corrections to the cross sections can be important. The Infra-Red (IR) finiteness of thermal field theories of charged fermions (fermionic QED) has been proven to all orders in perturbation theory. In this talk, after establishing the cancellation of IR divergences of charged scalar theories (scalar QED) at finite temperature at all orders in perturbation theory; I will describe the IR behaviour at finite temperatures, of a theory of dark matter interacting with charged scalars and fermions, which potentially contains both linear and sub-leading logarithmic divergences. I will show that the theory is IR-finite to all orders with the divergences cancelling when both absorption and emission of photons from and into the heat bath are taken into account. While 4-point scalar-photon interaction terms are known to be IR finite, we will show that their inclusion will lead to a neat factorisation and resummation. The result is generic and is applicable to a variety of models, independent of the specific form of the neutral-fermion-scalar interaction vertex.

ON PRIMORDIAL BLACK HOLES

Speaker: Richa Arya, PRL
Title: Origin of Primordial Black Holes from Warm Inflation
Based on arXiv:1910.05238
Abstract: Primordial Black Holes (PBHs) serve as a unique probe to the physics of the early Universe phenomenon, cosmic inflation. In light of this, we study the formation of PBHs by the collapse of overdensities generated during a model of warm inflation. Warm inflation is a description in which the inflaton dissipates into the radiation fields both during and after the inflationary phase. In our study, we discuss the role of the inflaton dissipation to the enhancement in the primordial power spectrum at the PBH scales. Our analysis shows that for some range of model parameters, we can produce an interesting abundance of tiny mass PBHs (~ 10^3 g) for our warm inflation model. Further, we also discuss the constraints on the initial mass fraction of the generated PBHs and the possibility of Planck mass PBH relics to constitute the dark matter.

Speaker: Sukannya Bhattacharya, PRL
Title: Primordial Black Holes and Gravitational Waves in a non-standard pre-BBN epoch
Abstract: A considerable abundance of PBH to be a potential candidate for cold dark matter is satisfied only when the primordial amplitude of scalar perturbations is quite large ($\sim 10^{-2}$) if PBH formation takes place during radiation epoch (RD). In alternate cosmological histories where additional epochs of arbitrary scalar field domination precede RD, the dynamics of PBH formation and relevant mass ranges can be different leading to lower requirement of primordial power at smaller scales of inflation. Moreover, this alternate history can modify the predictions the gravitational wave (GW) spectrum, specially in the second order of perturbation theory, which can be probed by upcoming GW observations.

Speaker: Mostafizur Rahman, JMI
Title: Origin of Extremal black holes
Abstract: One of most distinctive feature of the primordial black holes are that there is no restriction of its initial spin. However, the same conclusion may not be drawn for the black holes of steller origin. The unavoidable presence of accreting matters that surrounds a stellar black, reduces the maximum specific spin to a limiting value, $a^{*}_{limit}\approx .998$. Thus, the detection of a black hole with higher specific spin value than this limit will suggest its primordial origin. Considering a primordial black hole loses its mass and angular momenta only through Hawking radiation, Arbey et. al. have found the minimum initial mass value of these black holes.

Speaker: Devabrat Mahanta, IIT Guwahati (to speak on December 9)

Title: TeV scale Leptogenesis and Dark matter in non-standard cosmology

Abstract: We study the consequence of a non-standard cosmological epoch in the early universe on the generation of baryon asymmetry through leptogenesis as well as dark matter abundance. Since there is no compelling experimental evidence suggesting a radiation dominated universe prior to the epoch of big bang nucleosynthesis (BBN), we consider two different non-standard epochs: one where a scalar field behaving like pressure-less matter dominates the early universe, known as early matter domination (EMD) scenario while in the second scenario, the energy density of the universe is dominated by a component whose energy density red-shifts faster than radiation, known as fast expanding universe (FEU) scenario. While a radiation dominated universe is reproduced by the BBN epoch in both the scenario, the high scale phenomena like generation of baryon asymmetry and dark matter relic get significantly affected. We find that in two specific realization of EMD scenario, the scale of leptogenesis can be lower that in a standard cosmological scenario. Such a low scale scenario not only gives a unified picture of baryon asymmetry, dark matter and origin of neutrino mass but also opens up interesting possibilities for experimental detection.

Speaker: Ajit Srivastava, IoP

Title: Re-visiting gravitational wave events via pulsars

Abstract: By now many gravitational wave (GW) signals have been detected by LIGO and Virgo, with the waves reaching earth directly from their respective sources. These waves will also travel to different pulsars and will cause (tiny) transient deformations in the pulsar shape. The resultant transient change in the pulsar moment of inertia may leave an observable imprint on the extremely precisely measured pulsar signals, as detected on earth, especially at resonance. The pulsars may thus act as remotely stationed Weber gravitational wave detectors. This will provide opportunity for revisiting GW events (possibly several times, via different pulsars), helping in getting more information about the GW source as well as pulsar interiors. Also, it can help in better triangulation of the GW source location, which will be of crucial importance for GW sources which do not emit any other form of radiation such as black hole mergers. Further, pulsars may allows us to detect those events whose direct signals reached earth in past, hence were missed. We consider different GW events, including supernova events, and list specific pulsars whose signals will carry the imprints of these events in future. Importantly, even though the strength of the signal will depend on the interior properties of the pulsar, the expected dates of signal arrival are completely model independent, depending only on the locations of the source and the relevant pulsar.

OTHER TOPICS

Speaker: Piyali Banerjee, IIT Bombay

Title: New ultraviolet operators in supersymmetric SO(10) GUT and consistent cosmology

Abstract: We consider the minimal supersymmetric grand unified model (MSGUT) based on the group SO(10), and study conditions leading to possible domain wall (DW) formation. It has been shown earlier that the supersymmetry preserving vacuum expectation values (vev's) get mapped to distinct but degenerate set of vev's under action of D parity, leading to formation of domain walls as topological pseudo-defects. The metastability of such walls can make them relatively long lived and contradict standard cosmology. Thus we are led to consider adding a non-renormalisable Planck scale suppressed operator, that breaks SO(10) symmetry but preserves Standard Model symmetry. For a large range of right handed breaking scales MR, this is shown to give rise to the required pressure difference to remove the domain walls without conflicting with consistent big bang nucleosynthesis (BBN) while avoiding gravitino overproduction. However, if the walls persist till the onset of weak (thermal) inflation, then a low ~10−100 TeV MR becomes problematic.
