CONFERENCE PROGRAM

Monday 23rd January 2023

Chair: F. Finelli

14:00	(15)	**Welcome** *SOC*
14:15	(35+10)	**Primordial Magnetic Fields –Review (online)-** *SUBRAMANIAN, Kandaswamy* Online
15:00	(25+5)	**Cosmic Recombination and Primordial Magnetic-** *JEDAMZIK, Karsten*
15:30	***(30)***	***Coffee Break***
16:00	(15+5)	**Implications of deviations from slow roll for inflationary magnetogenesis-** TRIPATHY,Sagarika
16:20	(25+5)	**CMB observations: present and future –Review- Implications of deviations from slow roll for inflationary magnetogenesis-** *DE BERNARDIS, Paolo*
16:50	(15+5)	**Inflationary helical magnetic fields with a sawtooth coupling-** *CECCHINI, Chiara*
17:10	(25+5)	**Cosmological Magnetic Fields from the Electroweak Epoch (online)-** *VACHASPATI, Tanmay* Online
17:40	(40)	**Round Table: Magnetogenesis-** chair F. Finelli

Tuesday 24th January 2023

Chairs: K. Kunze (morning), F.Vazza (afternoon)

9:00	(25+5)	**The importance of Blazars in the cosmic magnetic field scenario – Review-** *RIGHI, Chiara*
9:30	(25+5)	**Multi-messenger constraints on cosmological magnetic fields-** *NERONOV, Andrii*
10:00	(25+5)	**Cosmic magnetism through the lens of gamma rays-** *ALVES BATISTA, Rafael*
10:30	(15+5)	**Density Perturbations sourced by Primordial Magnetic Fields-** *TRIVEDI, Pranjal*
10:50	***(20)***	***Coffee Break***
11:10	(15+5)	**Using the TXS 0506+056 Flare to Constrain Integralactic Magnetic Fields-** *SAVELIEV, Andrey*
11:30	(15+5)	**Effect of a primordial magnetic field on a warm inflation scenario-** *PICCINELLI BOCCHI, Gabriella*
12:00	***(120)***	***Lunch on your own***
14:00	(25+5)	**Simulating the origin and evolution of Magnetic Fields in large scale structures: Numerical challenges and the interplay with Turbulence and CRs –Review-** *DOLAG Klaus*
14:30	(25+5)	**Magnetogenesis in the first galaxies: the impact of seeding processes on galaxy formation-** *GARALDI, Enrico*
15:00	(25+5)	**Messengers from the Early Universe: Magnetic Fields, Turbulence, and Gravitational Waves-** *KAHNIASHVILI, Tina*
15:30	(15+5)	**Cosmological-scale magnetic fields from galactic outflows and search for primordial magnetic field**- *BONDARENKO, Kyrylo*
15:50	***(20)***	***Coffee Break***

16:10	(15+5)	**Illuminating the magnetised cosmic web (online)-** *O'SULLIVAN, Shane*
16:30	(25+5)	**Modelling the Evolution of Primordial Magnetic Fields-** *MTCHDLIDZE, Salome*
17:00	(15+5)	**Simulations of the Synchrotron Cosmic Web-** *BÖSS, Ludwig*
17:20	(40)	**Numerical discussion: what can we trust and what we still do not trust in numerical predictions of cosmic magnetism?-** *Chair F.Vazza*

Wednesday 25th January 2023

Chairs: R. Alves Batista (morning), E. Prandini (afternoon)

9:00	(25+5)	**Primordial magnetic field signals in the 21 cm background-** *KUNZE, Kerstin*
9:30	(25+5)	**Constraints on Primordial Magnetic Fields with Faraday Rotation. Impact of CMB foregrounds-** *RUBINO-MARTIN, Jose Alberto*
10:00	(25+5)	**Intergalactic Magnetic Field studies with the MAGIC telescopes-** *DA VELA, Paolo*
10:30	(15+5)	**Topological data analysis and complex network methods in analysing Cosmic Web (online)-** *TSIZH, Maksym*
10:50	***(20)***	***Coffee Break***
11:10	(25+5)	**Probing the intergalactic magnetic field through gamma-ray observations with the Fermi LAT and H.E.S.S. -** *MEYER, Manuel*
11:40	(15+5)	**The Polarisation Sky Survey of the Universe's Magnetism (POSSUM) -** *GAENSLER, Bryan*
12:00	***(120)***	***Lunch on your own***

14:00	(25+5)	**Intergalactic magnetic field constraints with VERITAS -** *PUESCHEL, Elisa*
14:30	(25+5)	**Prospects on the content of cosmic voids with the Cherenkov Telescope Array -** *BITEAU, Jonathan*
15:00	(15+5)	**Detectability of intergalactic magnetic field signatures from gamma-ray bursts with IACTs -** *MICELI, Davide*
15:20	(15+5)	**Intergalactic magnetic field studies by means of gamma-ray emission from GRB 190114C -** *MARTÍ-DEVESA, Guillem*
15:40	***(20)***	***Coffee Break***
16:00	(50)	**Round table: Limits from TeV data: status and future perspectives –** *chair:Elisa Prandini*

Get ready for the dinner – aperitifs in the center are strongly encouraged by the SOC!

20:00	**(depends on how much you drink)**	**SOCIAL DINNER!** **Cantina Bentivoglio Via Mascarella, 4/b, 40126 Bologna BO**

Thursday 26th January 2023

Chairs: M. Mayer (morning), G. Giovannini (afternoon)

9:30	(15+5)	**Constraints on anisotropic birefringence from Planck data-** *GRUPPUSO, Alessandro*
9:50	(15+5)	**Channeling astrophysical magnetic fields to the intergalactic medium via galactic outflows-** *LOPEZ RODRIGUEZ, Enrique*
10:10	(15+5)	**Density Perturbations sourced by Primordial Magnetic Fields-** *RALEGANKAR, Pranjal*
10:30	***(30)***	***Coffee Break***
11:00	(15+5)	**Constraints on the extragalactic magnetic field strength based on 145 months of Fermi-LAT observations and observable blazar spectrum modelling (online)-** *PODLESNYI, Egor*
11:20	(15+5)	**A systematic study of cosmic magnetogenesis scenarios with SWIFT-** *KARAPIPERIS, Orestis*
12:00	***(120)***	***Lunch on your own***
14:00	(15+5)	**Magnetic amplification at filaments knots in the distant Universe-** *DI GENNARO, Gabriella*
14:20	(15+5)	**Modelling primordial magnetic fields in galaxy clusters (online)-** *DOMINGUEZ FERNANDEZ, Paola*
14:40	(15+5)	**Cosmic Filaments as seen by eROSITA and LOFAR-** *BRÜGGEN, Marcus*
15:00	(15+5)	**The redshift evolution of extragalactic magnetic fields-** *POMAKOV, Valentin*
15:20	(15+5)	**Foreground Behavior and Cleaning, Perspective for B-Mode Reconstruction-** *BACCIGALUPI, Carlo*
15:40	***(20)***	***Coffee Break***

16:00	(15+5)	**IGMF and the apparent angular extension of Mkn421 at high energy gamma-rays -** *SOTOMAYOR WEBAR, Matias*
16:20	(25+5)	**Effects of magnetic field dissipation on the CMB -** *CHLUBA, Jens*
16:50	(15+5)	**Inhomogeneous recombination by primordial magnetic fields? -** *CIABATTONI, Alex*
17:10	(50)	**Round table: The bets are open! Choose your favorite champion in next generation of cosmological probes for primordial magnetism-** *Chair D. Paoletti*

Friday 27th January 2023

Chair:D. Paoletti

9:00	(15+5)	**Cosmic magnetic fields and chiral anomaly-** *BOYARSKY, Alexey*
9:20	(15+5)	**Subsonic Turbulence with Meshless Finite Mass-** *GROTH, Frederick*
9:40	(15+5)	**Suppression of the TeV Pair-beam–Plasma Instability by a Tangled Weak Intergalactic Magnetic Field (online)-** *ALAWASHRA, Mahmoud*
10:00	(25+5)	**Gravitational waves from (magneto)hydrodynamic turbulence at LISA and PTA-** *CAPRINI, Chiara*
10:30	(15+5)	**Inferring primordial magnetic properties from the resulting gravitational waves (online)-** *BRANDENBURG, Axel*
10:50	***(20)***	***Coffee Break***
11:00	(15+5)	**The Role of Viscosity in Cosmic Magnetic Fields-** *MARIN GILABERT, Tirso*
11:20	(15+5)	**Towards 21-cm intensity mapping with uGMRT (online)-** *ELAHI, Khandakar Md Asif*
11:40		***Conference Wrap-up***

Primordial Magnetic Fields - invited review (online) (14:15 - 15:00)

Primodial Magnetic Fields

- Presenter: Subramanian Kandaswamy

Cosmic Recombination and Primordial Magnetic Fields

- Presenter: JEDAMZIK, Karsten

The presence of primordial magnetic fields (PMFs) at recombination may be tested by current and future high precision CMB observations. The most sensitive impact on CMB anisotropies by PMFs seems to be baryon clumping on small scales. PMFs of weak strength could alleviate the Hubble tension, providing a tentative indirect detection of PMFs at recombination. I present first results of the most-up-to-date numerical simulations of the influence of PMFs on recombination, taking into account so far neglected effects.

Implications of deviations from slow roll for inflationary magnetogenesis

-Presenter: TRIPATHY, Sagarika

According to the paradigm of inflationary magnetogenesis, the magnetic fields observed on cosmological scales are generated by introducing a non-conformal coupling function in the standard electromagnetic action. Often, a parity violating term is also added to generate helical magnetic fields. In this talk, I will begin by discussing the effects of deviations from slow roll inflation on the spectra of non-helical and helical electromagnetic fields in single field models of inflation. I will show that sharp features in the scalar power spectrum generated due to departures from slow roll inevitably lead to strong features in the power spectra of the electromagnetic fields. Moreover, in certain instances, such effects can also considerably suppress the strengths of electromagnetic fields over the scales of cosmological interest. While it seems possible to undo the strong features in the electromagnetic power spectra in some situations, it is realized at the cost of severely fine-tuned non-conformal coupling functions. In the second part of the talk, I will illustrate that the challenges that arise in single field models can be circumvented when magnetogensis is achieved using two field models of inflation. I will present the results from our recent work wherein we have shown that, in two field models, with suitably chosen non-conformal coupling functions, we can obtain spectra of magnetic fields of the required strength and shape even in situations involving strong departures from slow roll. Lastly, I will discuss the imprints of the primordial magnetic fields generated in certain two field models on the anisotropies in the cosmic microwave background.

CMB observations: present and future

-Presenter: DE BERNARDIS, Paolo

We review the current status of CMB anisotropy, polarization and spectral distortion measurements, with particular attention to the impact of CMb measurements on the study of voids and filaments.

Inflationary helical magnetic fields with a sawtooth coupling

-Presenter: CECCHINI, Chiara

We study the generation of helical magnetic fields during inflation by considering a model which does not suffer from strong coupling or large back-reaction. We consider a hybrid axion-Ratra model where the EM part is coupled to a non-monotonic time-dependent function with a sharp transition during inflation. The magnetic power spectrum is scale-invariant up to transition and blue-shifted after that. Electromagnetic conformal invariance is recovered at the end of inflation. The subsequent evolution of the helical magnetic field is subjected to an inverse cascade mechanism. We apply this model of magnetogenesis to a specific framework, namely a scale-invariant model of quadratic gravity, which is known to allow for inflationary trajectories in agreement with observations. Scale-invariant inflation also provides a theoretical motivation for having a non-monotonic coupling. We show that magnetic fields as large as $\sim$ nG at present can be generated on Mpc scales. This result is obtained without significantly lowering the energy scale of inflation, as done in other works.

Cosmological Magnetic Fields from the Electroweak Epoch (online)

-Presenter: VACHASPATI, Tanmay

An extension of the Kibble mechanism to electroweak symmetry breaking shows the production of cosmologically significant magnetic fields.

The importance of Blazars in the cosmic magnetic field scenario

-Presenter: RIGHI, Chiara

Multi-messenger constraints on cosmological magnetic fields

-Presenter: NERONOV, Andrii

I will review the status of constraints on cosmological magnetic fields from observations in different astronomical messengers and perspectives for tightening of the constraints with next-generation gamma-ray, radio or gravitational wave instruments (or, ultimately, measurement of the field parameters for magnetic fields from cosmological phase transitions or Inflation).

Cosmic magnetism through the lens of gamma rays

-Presenter: ALVES BATISTA, Rafael

The origin of magnetic fields in the Universe is an open problem in cosmology. One of the most promising ways to probe intergalactic magnetic fields (IGMFs) is using gamma rays produced in electromagnetic cascades initiated by high-energy gamma rays in the intergalactic space. Because the charged component of the cascade is sensitive to intervening magnetic fields, it is possible to probe IGMFs by combining spectral, temporal, and angular information from distant sources of high-energy gamma rays such as blazars. In this talk I will describe how to detect and characterise IGMFs with gamma rays, giving particular emphasis to the modelling of electromagnetic cascades and the associated uncertainties.

Density Perturbations sourced by Primordial Magnetic Fields

-Presenter: TRIVEDI, Pranjal

A new kind of density perturbations can be sourced by primordial magnetic fields (PMF) via their Lorentz force in the early Universe, particularly around the epoch of recombination (z~1100). PMF-induced density perturbations are expected to be quite distinct from standard adiabatic perturbations. We present 3D MHD simulations to follow the growth and characteristics of these density perturbations alongside evolving PMFs for a range of magnetic field strengths. Our simulations cover the drag-dominated, transition and turbulent-decay phases of the cosmic magnetised baryon fluid across recombination (z~3000–300). The variation in the r.m.s. amplitudes, distribution functions and power spectra of both PMFs and their density perturbations can be traced over this redshift range. We find that over-densities from PMFs can grow to appreciable values but remain below unity, for ~0.1 nG magnetic fields, whether scale-invariant or casual. This leads to density clumping factors growing relatively slowly and remaining below unity over the PMF range ~0.02—0.2 nG. Further implications for PMF constraints from the CMB, for any Hubble tension and non-Gaussianity are discussed.

Using the TXS 0506+056 Flare to Constrain Integralactic Magnetic Fields

-Presenter: SAVELIEV, Andrey

The recent observations of high-energy neutrinos from the blazar TXS 0506+056 in association with a corresponding electromagnetic component in a broad range of wavelengths may be used to analyze the intrinsic properties of this object and the traversed medium. Here we show that intergalactic magnetic fields (IGMFs) can affect the intrinsic spectral properties of this object reconstructed from observations. In particular, we point out that the reconstructed maximum gamma-ray energy of TXS 0506+056 can be significantly higher if IGMFs are strong. Finally, we use this flare to constrain both the magnetic field strength and the coherence length of IGMFs.

Effect of a primordial magnetic field on a warm inflation scenario

-Presenter: PICCINELLI BOCCHI, Gabriella

I will present a review of the effects that a primordial magnetic field present during the inflationary epoch can have on a warm inflation scenario, both on the effective potential and on the inflaton decay process.

Simulating the origin and evolution of Magnetic Fields in large scale structures: Numerical challenges and the interplay with Turbulence and CRs (review)

-Presenter: DOLAG, Klaus

Cosmological structures form in a hierarchical way. Transport of potential energy from the large scale to small scale motions ("turbulence") as well as injecting large amount of energy from small scales to larger scales by astrophysical progresses ("star-formation", "AGN") leads to a very complex and violent state of the diffuse, baryonic material within large scale cosmological structures. The computational treatment of the combination of all these processes is very challenging under numerical aspects, as well as challenge our physical understanding of many fundamental processes in galaxy formation. I will try to give an overview how our (sometimes missing) understanding of these processes are still limiting our predictive power for forecasting magnetic field origin and evolution within large scale structures.

Magnetogenesis in the first galaxies: the impact of seeding processes on galaxy formation

-Presenter: GARALDI, Enrico

The origin of the ubiquitous cosmic magnetic fields remains one of the big open questions in astrophysics, with many different seeding mechanisms being proposed over the years. Recently, it has been shown that magnetic fields can be created in the ionizing photon shadow behind overdense regions around the first galaxies. I will present the first ever cosmological simulations of such seeding mechanisms, made possible by recent numerical advancements which couple together a radiation transport and a magneto-hydrodynamical solvers. I will display results from two simulation suites, one zooming on a single galaxy (hence reaching high resolution), and one focusing on large-scale properties of the Universe. Each suite also includes runs with more standard seeding mechanism, i.e. the Biermann battery, injection from supernova explosions, and a cosmological seed field. Each simulation include a state-of-the-art galaxy formation model, necessary in order to capture as well as possible the physics responsible for the magnetic field amplification, a necessary step in order to connect the seeding mechanisms to low-redshift observations. After discussing the evolution of magnetic fields under different seeding conditions, and after showing that at z~0 the simulated magnetic field in galaxies is completely agnostic to the injection mechanisms and consistent with available measurements, I will describe how the inter-galactic medium magnetisation is very different in the models investigated, and discuss comparisons with available constraints.

Messengers from the Early Universe: Magnetic Fields, Turbulence, and Gravitational Waves

-Presenter: KAHNIASHVILI, Tina

The detection of the relic magnetic fields through cosmological or astrophysical observations would provide a wealth of information about the conditions and composition of our universe in the first fractions of a second after the Big Bang. For example, the magnetic field induced gravitational radiation propagates almost freely throughout the cosmic history, and primordial gravitational waves reflect a precise picture of the universe at their time of production. A host of empirical observations are being used to probe cosmological magnetic fields in our universe today. The cosmological signatures include effects on primordial (Big Bang) nucleosynthesis, generation of relic gravitational waves, effects on the cosmic microwave background (CMB) temperature and polarization anisotropies, effects on the CMB energy spectrum via distortions, effects on the formation of stars and galaxies, and effects on the spatial distribution of large scale structure. Although these cosmological observations have not yet uncovered evidence for a primordial magnetic field, they provide valuable constraints on theoretically-compelling models of magnetogenesis. In my talk I will be focused on the origin, evolution and observational consequences of turbulence and magnetic fields, including physical processes in the early-universe. From the perspective of elementary particle physics, it is natural to expect that a primordial magnetic field may have arisen in the extreme environment of the early universe. Epochs at which the system is susceptible to large amplitude inhomogeneities provide especially strong candidates for magnetogenesis; these include cosmological phase transitions -- in a general sense, both the end of the inflation and thermal phase transitions are examples of cosmological phase transitions, The primordial plasma's high conductivity insures a strong coupling between the seed magnetic field and the fluid motions, and the plasma's high Reynolds number makes the plasma susceptible to the development of turbulence. After the seed magnetic field is formed at the magnetogenesis epoch, its subsequent evolution is governed by a coupling to plasma turbulence, decay due to adiabatic expansion and Alfv\'enic unfolding, and resistive dissipation. These effects must be taken into account in order to derive predictions for the observable signatures of primordial magnetism today. My talk will present a brief overview of different aspects of primordial magnetism.

Cosmic magnetic fields and chiral anomaly

-Presenter: BOYARSKY, Alexey

I will discuss how parity violation affects dynamics of magnetic fields in various systems.

Illuminating the magnetised cosmic web (online)

-Presenter: O'SULLIVAN, Shane

Radio-loud AGN can be observed throughout the majority of the history of the Universe and are thus excellent beacons for measuring the properties of the cosmic web and their evolution. In this talk, I will highlight recent results from the Low Frequency Array (LOFAR) telescope that use the effect of Faraday rotation to measure the evolution of the magnetic field strength in the filaments and voids of the cosmic web. Comparing this evolution with predictions from cosmological numerical simulations already enables us to distinguish between different scenarios for the origin of cosmic magnetism.

Modelling the Evolution of Primordial Magnetic Fields

-Presenter: MTCHDLIDZE, Salome

Primordial Magnetic Fields (PMFs), being good candidates for explaining the large-scale magnetisation of our Universe, evolve in a distinguishable fashion across different cosmological epochs. Their post-recombination structure and coherence scale depend on (i) details of the particular magnetogenesis model and (ii) evolutionary trends in the pre-recombination Universe. Inflation and phase-transition magnetogenesis scenarios lead to the infrared and blue spectra of initial seed fields, respectively. We study the evolution of such fields in the cosmic web and galaxy clusters. We take into account their pre-recombination magnetohydrodynamic (MHD) decay effects to evolve PMFs during structure formation. I will briefly review some of the processes that have been studied in the context of PMF evolution in the early and late Universes and the complexity in the modeling of the evolution of PMFs. I will present the results from our cosmological MHD, ENZO simulations which argue in favour of distinguishing between different primordial magnetogenesis scenarios on galaxy-cluster as well as on filamentary and cosmic voids' scales. I will compare our results with the results from other cosmological (or pure MHD) simulations and discuss future prospects for distinguishing different primordial magnetogenesis scenarios. Finally, the results of our studies will be presented in the context of rotation measure (RM) analysis while I will also discuss their relevance for the blazar spectra observations. Discriminating among different PMF models opens up the possibility of understanding the role of PMFs on the early-Universe processes, the thermalisation of the intergalactic medium (IGM; i.e., reionisation history of the Universe), and structure formation.

Simulations of the Synchrotron Cosmic Web

-Presenter: BÖSS, Ludwig

We present a part of the Simulating the LOcal Web (SLOW) project consisting of a cosmological non-radiative MHD simulation of a 500 Mpc h^-1 box including the spectral Cosmic Ray (CR) model presented in Böss et. al. (2022). I will briefly introduce the solver and show its application to predicting synchrotron emission from cosmic web filaments and accretion shocks around clusters, as well as implications of different magnetic field models on this emission.

Primordial magnetic field signals in the 21 cm background

-Presenter: KUNZE, Kerstin

There are several effects of large scale, cosmological magnetic fields which potentially could influence the 21 cm line signal. On the one hand primordial magnetic fields present since before decoupling influence the linear matter power spectrum. On the other hand due to the interaction with the cosmic plasma magnetic fields dissipate in the post recombination universe due to decaying MHD turbulence and ambipolar diffusion (or plasma drift). This leads to additional heating of matter and thus changes the thermal and ionisation history. In my talk I will address the implications of these effects on the 21 cm line signal and estimate its detectability with experiments such as the Square Kilometre Array (SKA).

Constraints on Primordial Magnetic Fields with Faraday Rotation. Impact of CMB foregrounds

-Presenter: RUBINO-MARTIN, Jose Alberto

Intergalactic Magnetic Field studies with the MAGIC telescopes

-Presenter: DA VELA, Paolo

Topological data analysis and complex network methods in analysing Cosmic Web (online)

-Presenter: TSIZH, Maksym

I will present a review of modern methods of topological data analysis and complex network analysis applied to the Cosmic web, formed by the large-scale distribution of matter. We will compare the advantages and disadvantages of both approaches and explore what new information and utilities can both of them bring to cosmological and extragalactic studies, compared to traditional cosmological tests and probes. Both approaches were first tested on cosmological simulation data, possessing the fullness of observational information, unlike the real catalogs. However, new large galactic catalogs open new perspectives for the usage of discussed fine instruments to reveal the nature of the Cosmic Web, and even the possible imprints of primordial magnetism on it.

Probing the intergalactic magnetic field through gamma-ray observations with the Fermi LAT and H.E.S.S.

-Presenter: MEYER, Manuel

Magnetic fields in galaxies and galaxy clusters are believed to be the result of the amplification of seed fields during structure formation. However, the origin of this intergalactic magnetic field (IGMF) remains unknown. Observations of high-energy gamma rays from distant blazars offer an indirect probe of the IGMF. Gamma-rays interact with the extragalactic background light to produce electron-positron pairs, which can subsequently initiate electromagnetic cascades whose gamma-ray signature depends on the IGMF. Here, we report on a new search for the cascade emission using a combined data set from the Fermi Large Area Telescope (LAT) and the High Energy Stereoscopic System (H.E.S.S.). Using state-of-the-art Monte Carlo predictions for the cascade signal, our preliminary results exclude an IGMF < 7e-16 G for a coherence length of 1 Mpc even when blazar duty cycles as short as 10 years are assumed. This improves previous limits by a factor of 2.

The Polarisation Sky Survey of the Universe's Magnetism (POSSUM)

-Presenter: GAENSLER, Bryan

The Polarisation Sky Survey of the Universe’s Magnetism (POSSUM; https://possum-survey.org/) commenced in November 2022, and is using ASKAP’s unique survey capabilities to transform our understanding of astrophysical magnetic fields. POSSUM’s core goal is to produce a “rotation measure (RM) grid” of 30–50 polarised background sources per deg^2 over 20,000 deg^2 over 0.8-1.1 GHz. One of the main science goals of POSSUM is to use Faraday rotation to measure and constrain the magnetic fields in filaments, voids and the IGM. I will present an overview of the POSSUM survey, will show initial results, and will discuss the prospects for studying IGM magnetism with POSSUM.

Intergalactic magnetic field constraints with VERITAS

-Presenter: PUESCHEL, Elisa

A non-zero intergalactic magnetic field (IGMF) is predicted to produce detectable effects on GeV-TeV gamma-ray cascade emission from blazars. Depending on the strength of the IGMF, cascade emission may be time-delayed or angularly broadened compared to the blazar's primary, unscattered emission. Ground-based imaging atmospheric-Cherenkov telescopes, such as VERITAS, have the precise angular resolution needed to search for magnetically broadened emission. We present VERITAS results on the search for extended gamma-ray emission, based on observations of seven strongly detected TeV blazars at a range of redshifts. The consequent constraints on the strength of the IGMF are discussed. Prospects for future studies are also considered.

Prospects on the content of cosmic voids with the Cherenkov Telescope Array

-Presenter: BITEAU, Jonathan

Gamma-ray astronomy offers one of the keys to studying cosmic magnetism. Although gamma rays are zero charge messengers, their interaction with photons of the cosmic optical and infrared background produces pairs of charged particles. These multi-TeV electrons and positrons are sensitive to the magnetic fields present in cosmic voids, where gamma rays propagate ~3/4 of their journey from extragalactic sources. The cooling of leptons by the inverse-Compton process, which is presumed to be the main energy-loss channel, produces an observational signature of large-scale magnetic fields. Lower limits on the amplitude of these fields are indeed provided today by the search for an excess signal of GeV-TeV gamma rays, possibly extended angularly. With a sensitivity gain with respect to current-generation instruments of a factor of five to ten above 20 GeV, the Cherenkov Telescope Array (CTA) under construction promises unparalleled constraints on cosmic magnetism. In this talk, I describe the potential of the observations planned in the Key Science Projects of the CTA. Not only will CTA's sensitivity and angular resolution allow us to constrain, or even measure, magnetic fields in cosmic voids, but it will also bring precise knowledge of the cosmic backgrounds responsible for the production of charged particles and of the primary gamma-ray spectra of extragalactic sources. This upcoming observational revolution at very high energies will enable both to break new ground on these subjects with CTA alone and also to take a retrospective look at the multi-wavelength emission of the most stable sources in time.

Detectability of intergalactic magnetic field signatures from gamma-ray bursts with IACTs

-Presenter: MICELI, Davide

Intergalactic magnetic field (IGMF) is thought to be the weakest magnetic field present in the voids of large-scale structure in the Universe. Recently, Cherenkov telescopes have developed new measurement techniques to probe the presence and the properties of IGMF with gamma-ray observations. Gamma-ray bursts have been proposed as interesting targets for the detection of a secondary "pair echo" emission. In this contribution we will investigate the feasibility of the detection of this secondary cascade emission from low-redshift GRBs for Cherenkov telescopes, taking GRB190114C properties as a proxy to identify future interesting events.

Intergalactic magnetic field studies by means of gamma-ray emission from GRB 190114C
-Presenter: MARTÍ-DEVESA, Guillem

The origin of the large-scale magnetic fields in the Universe is one of the long-standing problems in cosmology. To discriminate among the different explanations it is crucial to measure the intergalactic magnetic field (IGMF) in the voids among the galaxies. Gamma-rays coming from extragalactic sources can be used to constrain the IGMF due to their interaction with the intergalactic medium. Particularly, strong transients allow to constrain very weak IGMFs. We use CRPropa3 to propagate the measured very-high energy ($E > 100$ GeV) spectrum from GRB 190114C in the intergalactic medium. We then compute the expected cascade emission in the GeV domain for different IGMF settings and compare it with the Fermi/LAT limits for different exposure times.

Constraints on anisotropic birefringence from Planck data

-Presenter: GRUPPUSO, Alessandro

Channeling astrophysical magnetic fields to the intergalactic medium via galactic outflows

-Presenter: LOPEZ RODRIGUEZ, Enrique

Galactic outflows driven by starbursts can modify the galactic magnetic fields and drive them away from the galactic planes. I will present a novel approach to quantify the magnetic field in the galactic wind of the canonical starburst galaxy M82. We used HAWC+/SOFIA polarimetric observations and a potential field extrapolation commonly applied in solar physics. I will present the modification to the classical Davis-Chandrasekhar-Fermi method to account for large-scale flows in the estimation of the magnetic field strength, and the basics of the potential field extrapolation to obtain the magnetic field strength and structure in the halo of M82. Results show that the observed magnetic fields in the starburst region arise from the combination of a large-scale turbulent field associated with the outflow and a small-scale turbulent field associated with bow-shock-like features. We estimate that the turbulent kinetic and turbulent magnetic energies are in close equipartition up to ~2 kpc (measured), while the turbulent kinetic energy dominates at ~7 kpc (extrapolated). We conclude that the fields are frozen into the ionized outflowing medium and driven away kinetically, which implies that the magnetic field lines in the galactic wind of M82 are `open.' These results are of particular interest because they show a direct channel between the starburst core and the intergalactic medium, which can be refilled with astrophysical magnetic fields potentially affecting the measurements of primordial magnetic fields.

Dark matter minihalo production from primordial magnetic fields

-Presenter: RALEGANKAR, Pranjal

Primordial magnetic fields can enhance baryon perturbations on scales below the photon mean free path prior to recombination. However, these perturbations are suppressed if the magnetic Jeans length scale becomes larger than the scale of the perturbation. In this work, we show that the growth of baryon perturbation also causes a growth in dark matter perturbation, and the latter is not suppressed by magnetic pressure. Consequently, searches for dark matter minihalos can prove as valuable tools in the search for primordial magnetic fields with coherence scales below the magnetic Jeans length.

Constraints on the extragalactic magnetic field strength based on 145 months of Fermi-LAT observations and observable blazar spectrum modelling (online)

-Presenter: PODLESNYI, Egor

The parameter values of the extragalactic magnetic field (EGMF) presumably filling the intergalactic medium remain largely unknown. One of the possible methods to better constrain the EGMF parameter values is to observe blazars with hard spectra and compare the characteristics of the observed gamma-ray emission with model results, since observed gamma rays may be secondary in nature, with their characteristics depending on the EGMF parameters. In our work, we use 145 months of Fermi-LAT observations of the blazars 1ES 1218+304, 1ES 1101-232, and 1ES 0347-121, and imaging atmospheric Cherenkov telescope observations of the same sources. The observed spectral energy distributions (SEDs) are compared to those modelled with the full 3-dimensional intergalactic particle propagation Monte-Carlo simulation ELMAG 3.01 program for various values of the EGMF strength B between 10^{-19} G and 10^{-12} G dispensing of any a priori assumptions about a possible contribution of cascade gamma rays to the observed blazar gamma-ray emission and under various assumptions about the shape of the intrinsic source gamma-ray spectra and assuming the blazars are steady sources. We exclude B ≤ 10^{-17} G at 4σ level (for the assumed correlation length of 1 Mpc) for all four options of the intrinsic spectral shape considered, and demonstrate that under some values of

B the cascade contribution to the observed SED may be dominant and still fit to the data reasonably well. The talk is based on the paper https://doi.org/10.1093/mnras/stac2509.

A systematic study of cosmic magnetogenesis scenarios with SWIFT

-Presenter: KARAPIPERIS, Orestis

Numerical simulations can substantially support the study of the origin of cosmic magnetism. Simulation projects that simultaneously consider a plurality of seeding scenarios, resolve amplification processes and reach cosmological scales are however still somewhat scarce. Leveraging on algorithmic advances at the heart of the novel cosmological code SWIFT, and developing concurrently a suite of Modern Lagrangian Magnetohydrodynamical Solvers, each with a different formulation of Ideal Magnetohydrodynamics, we seek to make theoretical predictions for the large-scale structure of magnetic fields in the late-time universe for a variety of plausible magnetogenesis hypotheses, independent of biases introduced by the solver.

Magnetic amplification at filaments knots in the distant Universe

-Presenter: DI GENNARO, Gabriella

Mpc-scale diffuse radio emission, known as radio halos, are the best evidence of accelerated particles and magnetic fields in galaxy clusters. In the last decades, new low-frequency arrays have sensibly increased the number of clusters hosting diffuse radio emission, reaching also the poorly explored high-redshift regime. In this talk, I will present the results on LOFAR observations of distant clusters ($z>0.6$), and I will discuss the implication on the evolution of large-scale magnetic fields, and on particle acceleration.

Modelling primordial magnetic fields in galaxy clusters (online)

-Presenter: DOMINGUEZ FERNANDEZ, Paola

Primordial magnetic fields (PMFs) are possible candidates for explaining the observed magnetic fields in the Universe. In general, there are two competing scenarios of primordial magnetogenesis: inflationary and phase-transitional. In this work, we study the amplification of both inflation- and phase-transition-generated PMFs in a forming galaxy cluster using magnetohydrodynamic cosmological zoom-in simulations. In this talk, we will discuss how the initial magnetic conditions can restrict the efficiency of the overall amplification. We find more efficient magnetic amplification for the large-scale, inflationary models than the phase-transition-generated seed fields. Finally, we will discuss the possibility of distinguishing between different magnetogenesis scenarios in future observations.

Cosmic Filaments as seen by eROSITA and LOFAR

-Presenter: BRÜGGEN, Marcus

Cosmological simulations predict the presence of hot gas in filaments that connect clusters of galaxies. This hot gas is thought to be an important contribution to the missing baryons in the Universe. In recent years, searches for this gas have been conducted in the X-ray as well as the radio band. There have been detections in both bands for close cluster pairs. In the radio regime, it is not clear under which conditions synchrotron emission from relativistic electrons can be produced in filaments. In this contribution, we present our search for emission from filaments connecting clusters of galaxies using stacking techniques on eROSITA and LOFAR data. We compare our results to recent advances in theory and simulation.

The redshift evolution of extragalactic magnetic fields

-Presenter: POMAKOV, Valentin

Faraday rotation studies of distant radio sources can constrain the evolution and the origin of cosmic magnetism. We use data from the LOFAR Two-Metre Sky Survey: Data Release 2 (LoTSS DR2) to study the dependence of the Faraday rotation measure (RM) on redshift. By focusing on radio sources that are close in terms of their projection on the sky, but physically unrelated ('random pairs'), we measure the RM difference, ΔRM, between the two sources. Thus, we isolate the extragalactic contribution to ΔRM from other contributions. We present a statistical analysis of the resulting sample of random pairs and find a median absolute RM difference $|\Delta RM| = (1.79 \pm 0.09)$ rad m^{-2}, with $|\Delta RM|$ uncorrelated both with respect to the redshift difference of the pair and the redshift of the nearer source, and a median excess of random pairs over physical pairs of (1.65 ± 0.10) rad m^{-2}. We seek to reproduce this result with Monte Carlo simulations assuming a non-vanishing seed cosmological magnetic field and a redshift evolution of the comoving magnetic field strength that varies as $(1 + z)^{-\gamma}$. We find the best-fitting results $B_0 \equiv B_{comoving}(z = 0) \lesssim (2.0 \pm 0.2)$ nG and $\gamma \lesssim 4.5 \pm 0.2$ that we conservatively quote as upper limits due to an unmodelled but non-vanishing contribution of local environments to the RM difference. A comparison with cosmological simulations shows our results to be incompatible with primordial magnetogenesis scenarios with uniform seed fields of order nG.

Foreground Behavior and Cleaning, Perspective for B-Mode Reconstruction

-Presenter: BACCIGALUPI, Carlo

IGMF and the apparent angular extension of Mkn421 at high energy gamma-rays

-Presenter: SOTOMAYOR WEBAR, Matias

Primordial Intergalactic Magnetic Fiels (IGMF) are a long-lived cosmological question, they could have played a crucial role in the early evolution of the universe but efforts to discover its properties have been so far inconclusive, with only limits put in place using different methods and techniques, current limits allow strengths between 10^{-7} nG and 1 nG for a coherence length of 1Mpc. This primordial seed field is the progenitor of the μGauss fields currently detectable on structures through compression or dynamo amplification processes. The most promising observable test for small intensity IGMF in voids is the extended secondary emission that develops from cascades initiated by TeV blazar photons interacting with EBL through pair production, these charged component can then Inverse Compton upscatter CMB photons into a second generation of gamma-rays. The extent and spectrum of this secondary emission depends (among other few parameters) on the properties of the intervening IGMF. In this work, we aim to detect and characterize the extended secondary emission around the line of sight to a Fermi-LAT sample of nearby Extreme TeV Blazars (ETB). Our proposed method involves analyzing the available 14 years of data from Fermi-LAT, and fitting simulated models produced with ELMAG that include both the spatial distribution, as well as the spectrum for the extended component as it would be observed after developing under different IGMF strengths. We can obtain an improved sensitivity to this detection by fitting different flux states of the ETB sources independently. Prelim. We find evidence for an angular extension of 0.04 degrees around blazar MKN421. The extended emission is consistent with a IGMF of magnitude 10^{-16} Gauss and coherence length of 1 Mpc. This field properties are compatible with an astrophysicial origin. As expected we also find the cascade contribution to be more significant at the low-flux state. These results are allowed by most of the limits placed on the IGMF parameter space.

Effects of magnetic field dissipation on the CMB

-Presenter: CHLUBA, Jens

Inhomogeneous recombination by primordial magnetic fields?

-Presenter: CIABATTONI, Alex

We discuss the possibility of non-linearity in baryon inhomogeneities during cosmological recombination.

Cosmological-scale magnetic fields from galactic outflows and search for primordial magnetic field

-Presenter: BONDARENKO, Kyrylo

Primordial magnetic field, when it confidently discovered, would play as important role in cosmology as CMB or Large Scale Structure. However, its observation can be affected by the presence of the large-scale magnetic field of galactic origin, magnetic bubbles. In the series of works, we study the effects of galaxy formation physics on the magnetization of the intergalactic medium (IGM) using the IllustrisTNG simulations. We demonstrate that large-scale regions affected by the outflows from galaxies and clusters contain magnetic fields that are several orders of magnitude stronger than in unaffected regions with the same electron density. Moreover, like magnetic fields amplified inside galaxies, these magnetic fields do not depend on the primordial seed, i.e. the adopted initial conditions for magnetic field strength. We discuss the effects of these strong magnetic fields on ultra-high energy cosmic rays, gamma rays, and Faraday Rotation Measure. We show that using different observables one should be able to disentangle the effects of magnetic bubbles from the primordial magnetic field and discuss a strategy for future observations.

Subsonic Turbulence with Meshless Finite Mass

-Presenter: GROTH, Frederick

Subsonic turbulence is a difficult problem for many numerical methods to handle. We use our new implementation of Meshless Finite Mass (MFM) in OpenGadget3 to calculate decaying, subsonic turbulence. Comparing the performance to other methods, including Smoothed Particle Hydrodynamics (SPH) in OpenGadget3, and a moving and a stationary mesh using the publicly available AREPO code, we show that MFM performs best capturing the turbulent power spectrum and works down to very small Mach numbers. Overall, this is very promising for the accurate evolution of turbulence in the intra-cluster medium in upcoming simulations of galaxy clusters.

Suppression of the TeV Pair-beam–Plasma Instability by a Tangled Weak Intergalactic Magnetic Field (online)

-Presenter: ALAWASHRA, Mahmoud

We study the effect of a tangled sub-fG level intergalactic magnetic field (IGMF) on the electrostatic instability of a blazar-induced pair beam. Sufficiently strong IGMF may significantly deflect the TeV pair beams, which would reduce the flux of secondary cascade emission below the observational limits. A similar flux reduction may result from the electrostatic beam–plasma instability, which operates the best in the absence of IGMF. Considering IGMF with correlation lengths smaller than a kiloparsec, we find that weak magnetic fields increase the transverse momentum of the pair-beam particles, which dramatically reduces the linear growth rate of the electrostatic instability and hence the energy-loss rate of the pair beam. We show that the beam–plasma instability is eliminated as an effective energy-loss agent at a field strength three orders of magnitude below that needed to suppress the secondary cascade emission by magnetic deflection. For intermediate-strength IGMF, we do not know a viable process to explain the observed absence of GeV-scale cascade emission.

Gravitational waves from (magneto)hydrodynamic turbulence at LISA and PTA

-Presenter: CAPRINI, Chiara

Gravitational waves from primordial first order phase transitions offer interesting possibilities to probe physical processes at high energy scales, in the early universe. Several GW sources can act during, and in the aftermath, of the phase transition. Among these, this talk concentrates on the turbulent motion possibly generated in the surrounding plasma, and possibly accompanied by a magnetic field. I will present the outcome of (M)HD simulations as well as an analytical modelling of the turbulence, and discuss observational prospects at both LISA and PTA.

Inferring primordial magnetic properties from the resulting gravitational waves (online)

-Presenter: BRANDENBURG, Axel

Magnetic fields generated during inflation or during phase-transitions result in rather different gravitational wave signatures. In my talk, I will present results from recent high resolution numerical simulations. There are significant differences in the gravitational wave spectra from earlier analytic calculations. A particularly important feature is a sharp drop in the spectral power at frequencies above the peak value. In my talk, I will also address differences between vortical and acoustic turbulence, as well as the relation between magnetic helicity and circular polarization of the resulting gravitational waves.

The Role of Viscosity in Cosmic Magnetic Fields

-Presenter: MARIN GILABERT, Tirso

The impact of viscosity on the Intracluster Medium (ICM) is still under debate and it can be essential in mixing and turbulence processes and, therefore, the interaction of galaxies within galaxy clusters and the evolution of galaxies. For this reason, a deep study on the effect that viscosity has in the evolution of Galaxy Clusters from a numerical simulation point of view can give us a hint of gas properties and the dynamics going on in the ICM. The effect of viscosity is to suppress turbulence at small scales, producing a decrease of the dynamo effect, which leads to weaker magnetic fields in Galaxy Clusters.

Towards 21-cm intensity mapping with uGMRT (online)

-Presenter: ELAHI, Khandakar Md Asif

Post-reionization neutral hydrogen (HI) intensity mapping (IM) offers an efficient technique for mapping large-scale structures in the universe. We apply the Tapered Gridded Estimator (TGE) on a 24.4 MHz bandwidth uGMRT Band 3 data aiming HI IM at z=2.28. TGE allows us to taper the sky response, suppressing the wide-angle foreground contributions. Applying TGE, we estimate the multi-frequency angular power spectrum $C_{\ell}(\Delta\nu)$ from which we determine the cylindrical power spectrum $P(k_{\perp},k_{\parallel})$. This method naturally overcomes the issue of missing frequency channels. We introduce the Cross TGE, which cross-correlates two cross-polarizations (RR and LL) to estimate $C_{\ell}(\Delta\nu)$. The Cross TGE is expected to mitigate several effects like noise bias, calibration errors etc., which affect the `Total' TGE, which combines the two polarizations. The measured Cross $C_{\ell}(\Delta\nu)$ is modelled to yield maximum likelihood estimates of the foregrounds and the spherical power spectrum $P(k)$ in several k bins. Considering the mean squared brightness temperature fluctuations, we report a 2σ upper limit $\Delta_{UL}^{2}(k) \le (58.67)^{2}$ $\rm{mK}^{2}$ at $k=0.804$ $\rm {Mpc}^{-1}$ which is 5.2 times tighter than our previous estimate with the Total TGE. Assuming that the HI traces the underlying matter distribution, we have estimated $[\Omega_{HI} b_{HI}]$ where Ω_{HI} and b_{HI} are the HI density and linear bias parameters respectively. We obtain a 2σ upper limit $[\Omega_{HI}b_{HI}]_{UL} \leq 0.061$ from this approach. Using their contrasting decorrelation properties, we also use a foreground removal technique to distinguish the foregrounds and the 21-cm signal from the $C_{\ell}(\Delta\nu)$. We found $[\Omega_{HI} b_{HI}]_{UL} \leq 2.17 \times 10^{-2}$ which is although ~10 times larger than the expected value, nonetheless, ~3 times improved over the foreground avoidance approaches.