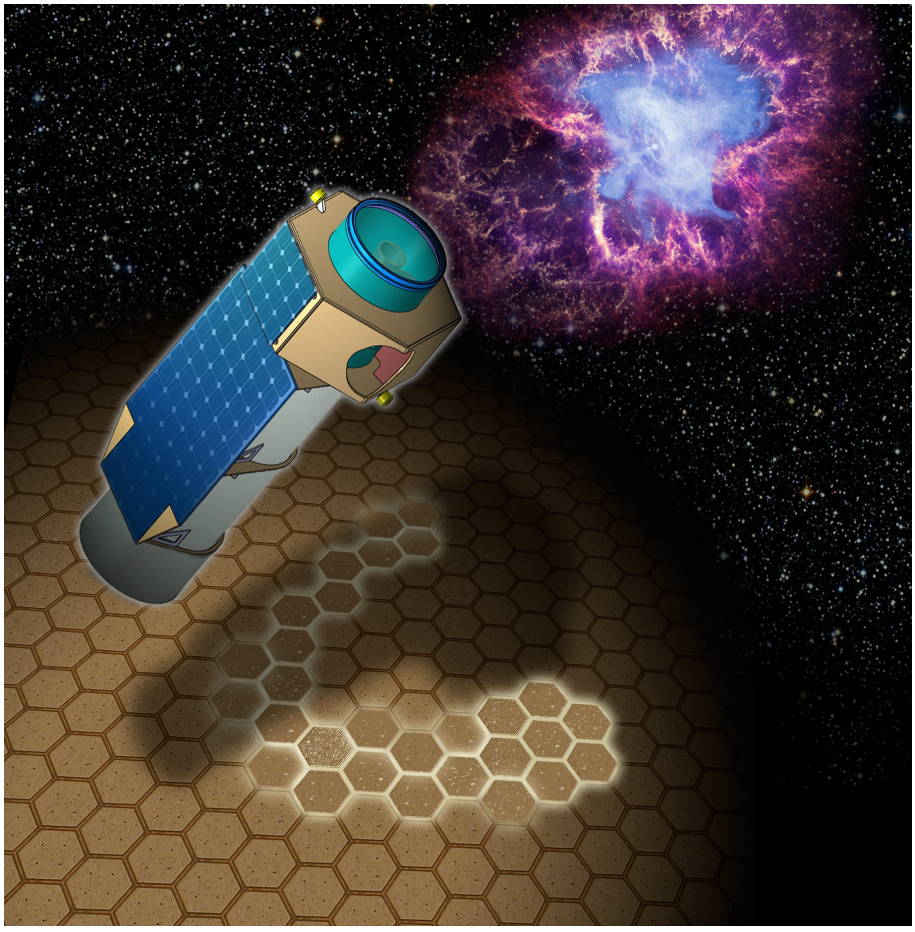

# SCIENTIFIC PROGRAM AND ABSTRACT BOOK



## SCIENTIFIC PROGRAM

### Monday, 23th May 2016 (afternoon)

16h00 – 18h00: Pre-registration (Committee room)

### Tuesday, 24th May 2016 (morning)

09h30 – 10h30: Arrival and registration
10h30 – 11h00: Conference opening speeches

11h00 – 12h40: **INTRODUCTORY SESSION**
11h00 – 11h10: Session opening and welcome by the XIPE P. I. (P. Soffitta)
11h10 – 11h40: The brief but long history of X-ray polarimetry (M. Weisskopf, invited)
11h40 – 12h10: State-of-the-art instrumentation for X-ray polarimetry (F. Muleri, invited)
12h10 – 12h40: The X-ray Imaging Polarimetry Explorer mission (D. Lumb, invited)
*12h40 – 14h30: Lunch break*

### Tuesday, 24th May 2016 (afternoon)

14h30 – 18h10: **SESSION 1 - ACCELERATION MECHANISMS IN PWNe, EXTRAGALACTIC JETS, SNe AND GRBs**
14h30 – 15h00: The Relationship between Particle Acceleration and Polarization (A. Marscher, invited)
15h00 – 15h30: Overview of the science case of WG 1 - Part I (J. Vink)
15h30 – 16h00: Overview of the science case of WG 1 - Part II (G. Tagliaferri)
*16h00 – 16h30: Coffee break and poster viewing*
16h30 – 16h50: Polarization properties of PWNe (N. Bucciantini)
16h50 – 17h10: Multi-Band Optical Polarization of Selected Blazars (S. Jorstad)
17h10 – 17h30: Expected polarization properties of radio-loud NL-Seyfert 1 galaxies (L. Foschini)
17h30 – 17h50: Numerical simulations of blazar polarization (P. Mimica)
17h50 – 18h10: Modeling polarized emission from relativistic outflows (T. Garrigoux)

*Evening: Welcome cocktail at the Valencia Town Hall*

### Wednesday, 25th May 2016 (morning)

09h30 – 12h50: **SESSION 2 - MAGNETIC FIELDS IN CATACLYSMIC VARIABLES AND NEUTRON STAR SYSTEMS**
09h30 – 10h00: Magnetic fields in cataclysmic variables and neutron star systems (A. Beloborodov, invited)
10h00 – 10h30: Overview of the science case of WG 2 - Part I (A. Santangelo)
10h30 – 11h00: Overview of the science case of WG 2 - Part II (S. Zane)
*11h00 – 11h30: Coffee break and poster viewing*
11h30 – 11h50: Polarization properties of pulsars (R. Mignani)
11h50 – 12h10: What can we learn from magnetar observations? (P. Cerda-Duran)
12h10 – 12h30: Polarized emission from highly-magnetized neutron stars (R. Taverna)
12h30 – 12h50: Polarized thermal emission from X-ray dim isolated neutron stars (D. Gonzales)
*12h30 – 14h30: Lunch break*

**Wednesday, 25th May 2016 (afternoon)**

14h30 – 18h30: **SESSION 3 – X-RAY POLARIZATION FROM SCATTERING IN AGNs AND THE GALACTIC CENTER**
14h30 – 15h00: X-ray polarization due to scattering and reprocessing(R. Antonucci, invited)
15h00 – 15h30: Overview of the science case of WG 3 - Part I (R. Goosmann)
15h30 – 16h00: Overview of the science case of WG 3 - Part II (F. Marin)
*16h00 – 16h30: Coffee break and poster viewing*
16h30 – 16h50: Exploring the Properties of AGN Coronas with X-ray Pol. Observations (H. Krawczynski)
16h50 – 17h10: On the polarization signal produced by Comptonization in accreting sources (F. Tamborra)
17h10 – 17h30: The optical pol. flare following the X-ray giant outburst of V0332+53 (A. Slowikowska)
17h30 – 17h50: Detecting and measuring variability in X-ray polarization properties (A. Ingram)
17h50 – 18h10: Influence of a polarized primary source on the X-ray polarization resulting from disc reflection in AGN (M. Dovciak)

*Evening: Social dinner*

**Thursday, 26th May 2016 (morning)**

09h30 – 11h50: **SESSION 4 - X-RAY POLARIMETRY AND FUNDAMENTAL PHYSICS: QUANTUM ELECTRODYNAMICS, STRONG AND QUANTUM GRAVITY, EXOTIC PARTICLES**
09h30 – 10h00: X-ray pol. at the interface between astrophysics and fundamental physics (J. Heyl, invited)
10h00 – 10h30: Overview of the science case of WG 4 - Part I (G. Matt)
10h30 – 11h00: Overview of the science case of WG 4 - Part II (E. Costa)
*11h00 – 11h30: Coffee break and poster viewing*

11h30 – 13h10: **FINAL SESSION – SIMULATIONS, OTHER PROJECTS IN X-RAY POLARIMETRY AND CONCLUSIONS**
11h30 – 11h50: XIPE Simulation tools (M. Pesce-Rollins, invited)
11h50 – 12h10: Ximpol: an X-ray polarimetry observation-simulation and analysis framework (L. Baldini)
12h10 – 12h30: Soft X-ray Polarimetry to Complement XIPE (H. Marshall)
12h30 – 12h50: Conference summary and closure – The future of X-ray polarimetry (P. Soffitta)

**POSTER SESSION DURING ALL COFFEE BREAKS**

P. Blay - Multiband polarimetry of X-Ray Binary systems

A. M.Bykov and Y.A.Uvarov - Polarized synchrotron X-ray emission from supernova shells

F. Capitanio - An observation strategy for transient X-ray binaries with Xipe

P. Connell - Simulating the Gas Pixel Detector of XIPE with LEPTRACK

N. Di Lalla - A Chandra-to-XIPE converter to assess the XIPE sensitivity for extended sources

J. Escada - Gas mixture optimization for the GPD focal plane of the XIPE mission

L. Foschini - Quantum gravity studies with XIPE

J. Navarro Gonzalez - Hot gas in galaxy clusters and its full velocity field

A. Marinucci - A XIPE observing program for Compton-thick AGN

E. Massaro - A model for the X-ray polarization of the Crab Pulsar

L. Ji - Polarization properties during the rising phase of type-I bursts in LMXBs

H. Stiele - Energy dependence of variability and accretion geometry in black hole LMXBs

A. Tortosa - X-ray emitting coronae in AGN: present status and perspectives for XIPE

M. Zajacek - Polarization properties of neutron star population in the Galactic center region

S. Zhang - Accreting X-ray ms pulsar as a possible probe of NS EOS

**INTRODUCTORY SESSION – ORAL PRESENTATIONS**

*Martin Weisskopf (invited)*

**The brief but long history of X-ray polarimetry**

The field of X-ray polarimetry has had an interesting history. Under the insight and leadership of Prof. Robert Novick, the Director of the Columbia Astrophysics laboratory the first X-ray polarimeters were conceived of and flown in sounding rockets at the end of the decade of the 1960's and early 1970's. This initial era saw the discovery of the integrated X-ray polarization from the Crab nebula thus unambiguously substantiating the presence of a large population of synchrotron photons in an ordered magnetic field. The initial excitement produced by this result led to a number of planned and actual satellite missions including the original version of the Einstein Observatory and an experiment launched on the Orbiting Solar Observatory-8 in 1975. The subsequent history of X-ray polarimetry was more arduous and involved, amongst other things the impact of politics as a result of the collapse of the Soviet Union. We will discuss the progress of the field both from a technical and historical perspective, concluding with a brief overview of where we stand today and the bright prospects for the future.

*Fabio Muleri (invited)*

**Instrumentation for X-ray polarimetry**

Different techniques can be used to measure the polarization in the X-ray energy range. The classical techniques, based on Bragg diffraction and Compton scattering and first used in the 1970s, are now complemented by polarimeters based on the photoelectric effect. Instrumentation based on these three techniques allows detecting polarization from a fraction of keV up to several hundred keV, offering the possibility of covering a very large number of scientific topics. Nonetheless, a trade-off is needed in practical implementations to design feasible instrumentation able to be launched in orbit. In this talk, I will review the techniques for measuring X-ray polarization, discussing the advantages and disadvantages of each.

*David Lumb (invited)*

**The X-ray Imaging Polarimetry Explorer mission**

I am going to give an overview ESA talk concerning the Phase A status, and XIPE in the M4 context.

## SESSION 1 - ACCELERATION MECHANISMS IN PWNe, EXTRAGALACTIC JETS, SNe AND GRBs – ORAL PRESENTATIONS

*Alan Marscher (invited)*

**The Relationship between Particle Acceleration and Polarization**

Acceleration of particles to ultra-relativistic energies seems to be easy for nature but quite difficult to explain theoretically. Except for radioactive decays, physical processes that seem capable of efficient particle acceleration involve magnetic fields that vary in time and space. One can therefore expect a relationship between the polarization observed in nonthermal emission from energetic cosmic phenomena and the dominant acceleration mechanism(s). The author will review how various proposals for energizing particles might be tested by observations of polarization of emission from high-energy plasma flows found in different astrophysical settings.

*Jacco Vink and Gianpiero Tagliaferi*

**Overview of the science case of WG 1 - Part I+II**

X-ray synchrotron radiation is an important source of radiation from many astrophysical high energy sources, where the origin is the highest energy electrons/positrons moving in a magnetic field. Synchrotron radiation is intrinsically polarized, but non-isotropy of magnetic fields along the lines of sight results in a degradation of polarization. Since the highest energy electrons lose their energy faster, the polarized X-ray synchrotron radiation is expected to vary more rapidly, and/or come from regions closer to the acceleration sites. Polarization measurements are key to finding out the role of magnetic turbulence for particle acceleration.

For diffuse X-ray sources like supernova remnants and pulsar nebulae, it is difficult to a priori predict whether the polarization fraction may be larger than in the radio, due to the larger emission volumes in the radio, or whether in effect the polarization fraction will be smaller, since regions of active acceleration may have more turbulent magnetic fields. For blazars the strong Lorentz boosts makes that we see only a small portion of the actual jet. The polarization fraction and its temporal variability can then be used to assess the length scales of magnetic field turbulence, which may be linked to the activity of the central engine. For bot microquasars and Tidal Disruption Event (TDE) X-ray polarization measurements allow us to study the jet and to constrain the physical processes responsible for the X-ray emission (synchrotron/IC). For microquasars this allows us to study scaled down versions of AGN, with alternating accretion/emission modes operating on shorter, accessible times scales. For the TDE the study allows us to see the evolution of a newly born jet.

Working group 1 covers also a few types of sources for which the role of XIPE is not clear:

GRBs prompt X-ray emission are likely to be strongly polarized, if the prompt is dominated by synchrotron emission. XIPE will not have the rapid response to allow for fast repointing, but a few bright GRBs seen by Swift have an X-ray flux of the order of a few millicracb even after 10-12 hours and for those XIPE could provide the first real sensitive X-ray polarimetric measurements.

Line emission from clusters of galaxies may be affected by resonant line scattering imprinting a radially dependent polarization signal. The polarization fraction is, however, below the limits that can be reached by XIPE. Finally, bremsstrahlung from magnetised electrons during stellar flares may also be polarized. The expected polarization fraction is expected to be weak, but nevertheless bright active stars may offer an opportunity to detect polarization.

*Niccolo Bucciantini*

**Polarization properties of PWNe**

I will present a numerical model of the polarized properties of PWNe, both with the use of semi-analytical description of the bright X-ray features and fully numerical simulations based on detailed multidimensional RMHD evolution. After reviewing the main results of numerical modeling, I will show that, in the case of the Crab Nebula, the emission properties of the brightest X-ray features (the wisps and the torus), already allow one to constrain the level of turbulence (the degree of magnetic fluctuations).

*Svetlana Jorstad*

**Multi-Band Optical Polarization of Selected Blazars**

I will present optical BVRI polarimetric and photometric observations for several blazars that are promising candidates to be observed with the X-ray Imaging Polarimetry Explorer. We monitor these blazars in the VLBA-BU-BLAZAR project (http://www.bu.edu/blazars/VLBAproject.html). I will describe timescales and amplitudes of variability of optical polarization, existence of preferable position angles of polarization and how they relate to the direction of the jet, and correlations between spectral indexes of total and polarized flux at optical wavelengths and between X-ray and optical spectral indexes. I will discuss parameters of X-ray polarization expected at 2-8 keV for single-zone models of the candidate blazars. The research was funded in part by NASA Fermi Guest Investigator grant NNX14AQ58G and Swift Guest Investigator grant NNX15AR45G.

*Luigi Foschini*

**Expected polarization properties of radio-loud narrow-line Seyfert 1 galaxies**

Radio-loud narrow-line Seyfert 1 galaxies (RLNLS1s) are active galactic nuclei (AGN) with powerful relativistic jets characterised by a relatively small central black hole mass (1-100 million solar masses) and a very high accretion rate (0.1-1 times the Eddington limit). We summarise the known polarization properties at radio and optical frequencies, and describe what is expected in the XIPE energy range. We also discuss similarities between the pc- and kpc-scale jet properties of RLNLS1s and those of typical blazars.

*Petar Mimica*

**Numerical simulations of blazar polarization**

I present results of preliminary numerical simulations of non-thermal emission from blazars (in the framework of the internal shocks model). The simulations are based on an improvement of the existing blazar code (Mimica & Aloy 2012) so that it can compute polarized emission. I show, among other things, how the polarization signal depends on the magnetic field strength and assumed orientation. Our model can handle arbitrarily strong magnetic fields and solves the equations of relativistic magnetohydrodynamics using an exact Riemann solver. The emission is computed using the radiation transport code SPEV (Mimica et al. 2009), taking into account light travel time and relativistic effects. Polarized synchrotron and inverse-Compton emission is computed numerically.

*Tania Garrigoux*

**Modeling polarized emission from relativistic outflows**

The X-ray and gamma-ray emission from highly energetic astrophysical sources such as Gamma-Ray Bursts and Active Galactic Nuclei, is believed to be produced primarily by two mechanisms: synchrotron radiation (SR) and inverse Compton scattering (ICS). The study of the polarization of the emission is an important tool in the analysis of these mechanisms. We investigate the polarization of photons produced by ICS of relativistic electrons on various target photon fields, including the CMB. We present polarization results over the whole energy spectrum, including the trans-relativistic regime, considering initially unpolarized photons and electrons in any spectral distribution.

**SESSION 1 - ACCELERATION MECHANISMS IN PWNe, EXTRAGALACTIC JETS, SNe AND GRBs – POSTER PRESENTATIONS**

*Long Ji*

**Polarization properties during the rising phase of type-I bursts in LMXBs**

Thermonuclear (type I) X-ray bursts are the unstable explosions on the surface of neutron stars. In the rising phase, the burst can be regarded as a small hot spot, of which the radiation is isotropic. A polarization signal emitted by such a hot spot is expected. In this poster we describe the numerical solution of the polarization properties during the rising phase of type-I bursts in LMXBs.

*Andrei Bykov and Y. A.Uvarov*

**Polarized synchrotron X-ray emission from supernova shells**

Young supernova remnants are known to be relativistic particle accelerators with likely efficient amplification of turbulent magnetic fields. Turbulent field amplification is a generic part of the diffusive shock acceleration concept. The broad nonthermal synchrotron continuum emission produced by accelerated electrons in young SNRs may span from radio to X-rays. High resolution radio images revealed polarized radiation from a number of SNRs including Tycho, SN 1006, Kes 69, W44, IC 443 etc.

Synchrotron X-rays are emitted by multi-TeV regime electrons which are expected to survive against the energy losses only in the narrow filaments around the shock where the magnetic field is highly turbulent. Narrow synchrotron X-ray filaments were detected indeed with the arcsecond resolution by Chandra in SN 1006, Cas A, Tycho, RCW 86, RX J1713.7-3946 and others. While the lack of Faraday depolarization in X-rays is a favorable factor the degree of polarization of synchrotron X-ray emission in a turbulent field is a matter of the spatial resolution of the X-ray polarimeter. We present model images of the polarized X-ray emission from synchrotron supernova shells simulated within the frame of a diffusive shock acceleration model with anisotropic turbulent magnetic field amplification. The images presented are for different spatial resolutions of the X-ray polarimeter. We show that the polarized X-ray emission could be detected from Tycho's SNR with the expected sensitivity and resolution of XIPE for some models of an anisotropic turbulent magnetic field. These observations would help to constrain the models of particle acceleration in supernova shocks.

*Javier Navarro Gonzalez, Susana Planelles Mira*

**Hot gas in galaxy clusters and its full velocity field**

Galaxy clusters, the largest gravitationally bound structures in the Universe, with typical masses of $10^{14}$-$10^{15}$ $M_{sun}$, are mainly formed by dark matter (~80%), hot gas (~15%) and a subdominant stellar component. The hot gas in clusters, the intra-cluster medium (ICM), contains the most part of their baryonic content. Given the typical ICM temperatures (~2-10 keV), galaxy clusters can be observed in X-rays. In this poster we present a preliminary analysis of the temperature and velocity fields of a simulated galaxy cluster as obtained from a simulation performed with an Eulerian-AMR cosmological code. By analyzing the distribution of the X-ray emitting gas together with the full velocity field of each gas element, we discuss the conditions under which a given degree of polarization may arise.

## SESSION 2 - MAGNETIC FIELDS IN CATACLYSMIC VARIABLES AND NEUTRON STAR SYSTEMS – ORAL PRESENTATIONS

*Andrei Beloborodov (invited)*

**Magnetic fields in cataclysmic variables and neutron star systems**

Magnetic fields in accreting white dwarfs and neutron stars will be reviewed. Strongly magnetized compact objects shape the accretion flows in binary systems and influence the spectrum and polarization of the produced X-ray emission. Magnetic fields also play a key role for the emission from isolated neutron stars powered by their stored heat, rotation, or magnetic energy.

*Andrea Santangelo*

**Overview of the science case of WG 2 - Part I**

In this talk I will report on the structure, status and science context of the XIPE working group on magnetic fields in Cataclysmic variables and neutron stars (working group 2.). I will then present the specific science case and scientific activities for accreting X-ray pulsars (working group 2.3) and CVs and Novae (working group 2.1). Accreting X-ray pulsars have been at the core of X-ray polarization interest since the seminal work of Meszaros and colleagues, who have shown how phase resolved measurements of the fraction and angle of X-ray polarization might help to understand the geometry and physics of the beam pattern formation in these systems. These measurements might allow us to ultimately discriminate between the different models predicting how X-ray emission is formed in these systems. I will, in addition, discuss the science background of X-ray polarization studies, and the potential of XIPE, for studies of magnetic and non magnetic CVs, and Novae. Surprisingly observed at hard X-rays and GeV energies, accreting WD binaries have recently been at the center of a renewed interest of the high energy community.

*Silvia Zane*

**Overview of the science case of WG 2 - Part II**

I will report on the scientific activities of two sub-WGs: WG 2.2 (accreting ms pulsars) and WG 2.4 (magnetars and RPPs) and summarize the expected performance and scientific return of XIPE for these object classes.

*Roberto Mignani*

**Polarization properties of pulsars**

Polarization measurements of pulsars offer unique insights into their highly-magnetised relativistic environments and represent a primary test for neutron star magnetosphere models and radiation emission mechanisms. Besides the radio band, optical observations have been, so far, best suited to reach these goals together with polarization measurements in the X-rays becoming possible in the near future thanks to missions, such as XIPE and IXPE. In this talk, we review the status of the optical polarization measurements of pulsars and we foresee possible synergies between X-ray polarimetry observations of selected pulsars with, e.g XIPE and IXPE, and optical observations with the next generation of extremely large telescope, such as the E-ELT.

*Pablo Cerda-Duran*

**What can we learn from magnetar observations?**

Soft gamma repeaters (SGRs) are believed to be strongly magnetized neutron stars (magnetars) showing frequent flare activity due to the rearrangement of the magnetic field and the cracking of the solid crust. In the X-ray tail of the three observed giant flares the presence of quasi-periodic oscillations (QPOs) has been observed, which may be related to oscillations of the neutron star interior. Their persistent emission includes a non-thermal component that has been linked to resonant cyclotron scattering (RCS) on a twisted magnetosphere. In that case emission is polarized and is one of the targets of XIPE. I will review the status of the modelling of QPOs and present our latest numerical results regarding this scenario. I will present force-free twisted magnetospheres calculations coupled to the internal oscillations of a neutron star, and present simple Monte-Carlo calculations of the X-ray spectrum.

*Roberto Taverna*

**Polarized emission from highly-magnetized neutron stars**

Highly-magnetized neutron stars exhibit the strongest magnetic fields ever observed in the universe ($10^{13}$-$10^{15}$ G) and provide the only laboratories where physics in the presence of magnetic fields exceeding the quantum critical limit can be tested. Observationally identified with the Anomalous X-ray Pulsars and the Soft Gamma Repeaters (AXPs and SGRs, the magnetar candidates) and with other peculiar X-ray pulsars, like the X-ray Dim Isolated Neutron Stars (XDINSs), their properties have been, up to now, investigated through spectroscopic and timing measurements. Nevertheless, these analyses alone are far from providing complete information. In this respect, X-ray polarimetry may disclose an entirely new approach. Radiation emitted in the presence of strong magnetic fields, in fact, is expected to be highly polarized. Measurements of the linear polarization fraction and the polarization angle can unambiguously determine the model parameters also when spectral analysis alone fails. The polarization signal that an observer at infinity collects, however, do not necessary coincide with model predictions for the polarization at the surface, due to the effects of quantum electrodynamics in the highly magnetized vacuum around the star, coupled with the rotation of the Stokes parameters in the plane perpendicular to the line-of-sight, induced by the non-uniform magnetic field. I present the results of the numerical codes developed to simulate the polarization pattern of the radiation emitted from highly-magnetized, isolated neutron stars under different conditions. I show that polarization measurements can indeed provide key information about the physical and geometrical properties of these sources, allowing to directly test theoretical models. Numerical results are also used to generate simulated data for new-generation X-ray polarimeters, currently under development, like the X-ray Imaging Polarimeter Explorer (XIPE).

*Denis Gonzalez*

**Polarized thermal emission from X-ray dim isolated neutron stars**

The physical conditions at the surface of strongly magnetized neutron stars are still under debate. In particular, it is unclear whether a strong magnetic field, such as that present in X-ray dim isolated neutron stars (XDINSs), may drive a phase transition turning a gaseous atmosphere into a condensed surface. Here we investigate the polarized thermal emission from XDINSs, taking RX J1856.5-3754 as a representative case. I will present the results of our polarized radiative calculations of the optical and X-ray emission, that takes into account QED effects in the magnetized vacuum outside the star, in addition to the magnetic configuration and geometry of the system. Our calculations have shown that an atmosphere and a condensed surface will give very different phase-averaged polarization fraction and polarization angle, thus combining the measurements in optical and keV X-ray polarimetry we can distinguish the physical conditions on the neutron star surface. Our results may therefore be relevant in view of future developments of soft X-ray polarimeters.

## SESSION 2 - MAGNETIC FIELDS IN CATACLYSMIC VARIABLES AND NEUTRON STAR SYSTEMS – POSTER PRESENTATIONS

*Enrico Massaro*

**A model for the X-ray polarization of the Crab Pulsar**

We present preliminary estimates of the expected polarization signal of the Crab Pulsar in the 3-10 keV energy range, based on a multicomponent model reproducing the main broad band features of the pulsed emission (Massaro et al. 2006). We computed the polarization fraction and angle as a function of the pulse phase under the assumption that some or all the X ray components have the same polarization properties of the optical components as measured with OPTIMA (Slowikowska et al. 2009), and evaluated the XIPE observing time necessary to reach the statistics sufficient to distinguish the various scenarios.

*Shu Zhang*

**Accreting X-ray ms pulsar as a possible probe of NS EOS**

The equation of state of NS is one of the core sciences for the future mission. Regarding possible probes, apart from the bursting ms pulsars for which the relation between the spinning light curve and the mass/radius of NS is well established theoretically, accreting X-ray ms pulsars are potential alternatives. However, the emission mechanism of the latter is more complicated since one has to account for the corona on top of the NS surface which provides Comptonization that mixes/distorts the black body underneath. Thus disentangling the model components between the black body and the Comptonization becomes a big challenge in case of relating the spinning light curve to the mass/radius of NS. This problem is hard to handle even with a powerful telescope owning a very large detection area. X-ray polarimetry shows us a new insight on model discrimination, and we take the accretion X-ray ms pulsar XTEJ1751-305 as an example to show how this issue could be addressed with a polarization telescope.

## SESSION 3 – X-RAY POLARIZATION FROM SCATTERING IN AGNs AND THE GALACTIC CENTER – ORAL PRESENTATIONS

*Robert Antonucci (invited)*

**X-ray polarization due to scattering and reprocessing**

The Unified Model for Seyferts, radio galaxies, and quasars can be traced to the discovery of hidden nuclei by means of optical spectropolarimetry. In a few cases like NGC 1068, the scattering particles are robustly identified as free electrons, but in others dust scattering plays a role. But in general, existing optical observations are inadequate to separate the two. In Type 2 AGN, there is often a faint constant X-ray power law detected below the absorption cutoff energy for the nuclear emission, which is usually attributed to electron-scattered nuclear light. XIPE can check this for the brightest objects! Given the optical polarized flux, electron scattering makes a clear specific prediction for the X-ray scattering/polarized flux, and confirmation of electron scattering would give us robust physical information for interpreting both wavebands. In the case of some high redshift radio galaxies, much of the light comprising the "alignment effect" is scattered from hidden quasars; if electron scattering can be confirmed, then $>\sim 10^{12}$ $M_o$ of relatively cool gas ($<10^6$ K) exists unstably, and may indicate some kind of monolithic collapse of the most massive galaxies.

*René Goosmann*

**Overview of the science case of WG 3 - Part I**

I am going to summarize the role XIPE can play in measuring the polarization emerging from aspherical emission and scattering scenarios. Compton scattering models are applied to accreting black holes in X-ray binaries and explain the production of the underlying X-ray continuum in a disk corona. Reprocessing of the primary emission in relatively colder material of the accreting or ejection flows may further alter the polarization before the radiation escapes from the source. All these interactions between X-rays and matter is encoded in the polarization state to be determined by XIPE and interpreted using adequate modeling.

*Frédéric Marin and Eugene Churasov*

**Overview of the science case of WG 3 - Part II**

I am going to extend the lines of thought given in the first part of the overview towards the supermassive black holes present in Seyfert galaxies and other active galactic nuclei. I am going to discuss these sources for different accretion states. The overview includes the very low-luminosity supermassive black hole at the Center of our Galaxy. For the latter, X-ray polarimetry is going to allow us to test in a unique and unambiguous way if the X-ray brightness of several molecular clouds in the environment of Sgr A* is due to a past activity phase of the black hole. If this is the case, observations with XIPE would even decipher the 3D geometry of the reprocessing material.

*Henric Krawczynski, Janie Hoormann, Banafsheh Beheshtipour*

**Exploring the Properties of AGN Coronas with X-ray Polarimetric Observations**

X-ray polarimetric observations of Active Galactic Nuclei (AGN) give us a new handle to constrain the geometry and physical parameters of the AGN accretion disk and their coronas. We have performed a series of general relativistic ray tracing studies to explore the spectral, spectropolarimetric, and reverberation signature of different 3-D corona geometries. In this contribution, I will highlight recent results from simulation runs with different corona geometries. Furthermore, I will discuss strategies for constraining the black hole, accretion disk, and corona parameters based on combining information from all observational channels (energy spectra, polarization, and timing).

*Francesco Tamborra*

**On the polarization signal produced by Comptonization in accreting sources**

The X-ray spectrum observed in AGN and XRBs is believed to be produced through Comptonization by a hot corona of electrons surrounding the accretion disc and whose physical parameters such as thermal energy, optical thickness and geometry are mainly unknown. In this scenario the X-ray radiation produced by scattering should show a polarization signal characteristic of the scattering material geometry responsible for its production. In this talk we will explore how the polarization signal may differ according to different geometries of the corona and if XIPE could be the capstone which will allow us to finally put constraints on the geometry and the other physical properties of the corona.

*Agnieszka Slowikowska*

**Discovery of the optical polarization flare following the X-ray giant outburst of V0332+53**

V0332+53 is a transient Be X-ray binary that went through a giant outburst between June 2015 and October 2015 registered by the Gamma-ray Burst Monitor (GMB) on board of the Fermi satellite. We present the discovery of a flare of linearly polarized optical light in V0332+53 that followed the X-ray outburst. We monitored the source with the multi-wavelength optical polarimeter RINGO3 on the 2-m fully robotic Liverpool Telescope located at the Observatorio del Roque de Los Muchachos on La Palma. RINGO3 measures polarization simultaneously in three spectral wavelength bands: blue (350-640 nm), green (650-760 nm) and red (770-1000 nm). The polarized optical flare went off around 90 days after the X-ray burst and lasted another 90 days in all three wavelength bands of RINGO3. The polarization degree reached up to 6% in blue and up to 4% in red, while the PA changed by more than 100 degrees during the flare. This is the first detection of optical polarization flare of high mass X-ray binary correlated with a preceding X-ray outburst. Our observations shed new light on the activities of X-ray binaries.

*Adam Ingram*

**Detecting and measuring variability in X-ray polarization properties**

X-ray variability analysis, particularly when combined with spectral information, has proved a powerful tool for probing accretion flows onto compact objects. The dawn of X-ray polarimetry introduces further information with which to map the accretion flow and track the propagation of mass accretion rate fluctuations towards the compact object. Since the physically interesting quantities are the polarization degree and angle, a great amount can be learned by detecting and characterising variability in these two quantities. However, it is not possible to directly measure a high resolution time series of these two quantities. Instead, we can measure time series for the Stokes parameters, and from that somehow infer the Fourier properties of the polarization degree and angle. I will present a method to analytically calculate the Fourier transform of the Stokes parameters, given a phenomenological model for the Fourier transform of the polarization degree and angle. I will show that fitting this model to the measured Fourier properties of the Stokes parameters gives a general way to reconstruct the Fourier properties of the polarization degree and angle. This will apply to quasi-periodic variability, perhaps created by Lense-Thirring precession of the inner accretion flow which would produce a modulation in the polarization angle, and also to broad band variability, which could produce a modulation in the polarization degree as random fluctuations propagate from regions of low to high polarization.

*Michal Dovciak*

**Influence of a polarized primary source on the X-ray polarization resulting from disc reflection in AGN**

Theoretical computations showed that the reflection of X-ray radiation from the accretion disc in AGN should result in significant (detectable) polarization signals. Originating from a primary power-law coronal emission situated above the disc surface, X-ray photons are partially reprocessed by Compton scattering in the disc material and show a polarization level that heavily depends on the geometry of scattering. In this contribution, we examine the polarization that can be obtained in the lamp-post geometry scenario, where a compact patch of corona is positioned on the axis above the black hole. Up to now only unpolarized primary emission was considered. We will show the results of a more likely scenario where the primary X-ray photons are already partially polarized by up-scattering in the hot corona. The influence of a differently polarized primary source will be presented.

Picking the right direction

Xipe

The Host Country and the Conference Sponsors have the pleasure to welcome you to Valencia on the occasion of the FIRST XIPE Science Meeting and are delighted to invite all attendees to the Social Dinner on Wednesday 25th May.

Time: 20:30h
Place: Terrace Lounge of the Hotel Astoria Palace (Plaza de Rodrigo Botet 5)

MENU

Soft drinks, beer, vermouth , campari ,
martini and juices
White, red and "fino" wine (DO Valencia)
Skewer grape with manchego cheese marinated in rosemary
Guacamole with tuna spoons
Crispy potatoes with "brava" sauce
Cod bites
*****
"Tapas" to share:
Sauteed baby squid with spring garlic
Sardines and caramelized onion with ratatouille "coca"
Fried potatoes with quail eggs mini pan
Homemade croquettes

Rice with free range chicken, mushrooms and pumpkin

Mandarin soup with creamy chocolate
Coffee and tea
Red wine Marqués de Requena (DO. Utiel-Requena)
Beer, soft drinks and mineral waters

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## SESSION 3 – X-RAY POLARIZATION FROM SCATTERING IN AGNs AND THE GALACTIC CENTER – POSTER PRESENTATIONS

*Pere Blay*

**Multiband polarimetry of X-Ray Binary systems**

Polarimetry is an excellent tool to gather information from X-Ray binary systems, where most of the ingredients needed to produce polarization are found (accretion/decretion discs, jets, eclipses, etc). We present the first results of an intensive monitoring campaign on polarization of X-Ray binaries form the Nordic Optical Telescope (La Palma, Spain). Multiband optical polarimetry allows for a detailed analysis of the intrinsic and interstellar polarization and complements high energy observations. Combining both sets of data a deeper understanding of the source and its neighborhood is achieved.

*Fiamma Capitanio*

**An observation strategy for transient X-ray binaries with XIPE**

X-ray binaries (XRBs) are good targets for XIPE because of the high brightness that allows us to reach good sensitivity. Moreover polarimetry is a powerful investigation technique for a number of characteristics of these sources which are difficult to be constrained with other techniques. Then, it could be good to observe with XIPE as many XRBs as possible to fully cover the unclear aspects of them. However most of the XRBs are transient sources and if we assume that XIPE cannot have external triggers for TOOs, it is necessary to create a strategy in order to maximize the probability to catch these sources in outburst. Considering the time devoted to transient monitoring, if this time will be used to regularly observe the transient XRBs with an observation every 15 days, XIPE will monitor only 6 XRBs. We propose a study on more refined strategies of observation in order to minimize the time-wasting observing XRBs in quiescence and maximize the number of transient XRBs that could be observed by XIPE. Several attempts to predict the outburst waiting time of the XRBs can be found in the literature. Moreover looking at the X-ray light curves of XRBs, in very few cases, it is possible to extract with good confidence a period of recurrence that could be always the same for more than 40 years as in the case of the BHC 4U1630-472, or vary after 3 or 4 subsequent outbursts as in the case of H1743-322. Hoverer nowadays the literature lacks in systematic studies on the recurrence period for XRBs especially on NS XRBs.

*A. Marinucci, S. Bianchi, R.W. Goosmann, F. Marin, G. Matt*

**A XIPE observing program for Compton-thick AGN**

In the XIPE 2-8 keV energy band, Compton-thick AGN are dominated by radiation reflected (and thence polarized) either by neutral, optically thick matter (the "torus") or by ionized, optically thin, matter (possibly identified with the "warm mirror" responsible for the well-known optical scattering of the Hidden Broad Line Regions in Seyfert 2s). Here we discuss a possible observing program of Compton-thick AGN with XIPE, aiming to provide valuable insights on the geometry of the reflecting regions in the brightest sources of this class.

*Holger Stiele*

**Energy dependence of variability and accretion geometry in BH low mass X-ray binaries**

In low mass BH X-ray binaries (BHXBs), a stellar mass black hole accretes matter from its low mass companion star. Due to conservation of angular momentum the accreted matter forms a disc surrounding the compact object. This geometrically thin accretion disc emits a disc-blackbody spectral component. In addition, a power law component results from Compton up-scattering of soft seed photons by a cloud of hot electrons close to the black hole. The exact geometry of the Comptonizing cloud is still a matter of debate. Here we present the results of a comprehensive variability study of a sample of BHXBs, including a thorough study of covariance spectra. We will discuss the implications of these findings for the picture of the accretion geometry in BHXBs. Another method to put constraints on the accretion geometry is to measure the polarization degree of the Comptonized emission. XIPE will allow us to perform these measurements.

*Alessia Tortosa*

**X-ray emitting coronae in AGN: present status and perspectives for XIPE**

The primary X-ray emission of Seyfert 1 galaxies is widely believed to originate in the Comptonization of thermal disc photons by a population of hot electrons (usually called "hot corona"). The radiation is expected to be polarized, the polarization degree depending mainly on the geometry and optical depth of the corona. NuSTAR observations are providing for the first time high quality measurements of the coronal physical parameters - temperature and optical depth. We here summarize the NuSTAR results and discuss their implications for X-ray polarimetric meaurements with XIPE.

*Zajacek, M.; Karas, V.; Eckart, A.; et al.*

**Polarization properties of neutron star population in the Galactic center region**

We analyse the emission properties of neutron stars that are predicted to exist in large numbers of the order of 10000 in the innermost parts of the Galactic Center. A part of the population of isolated neutron stars propagates supersonically through denser ionized streams of the Minispiral (Sgr A West), forming bow shocks where particles are accelerated in strong magnetic fields producing a polarized X-ray synchrotron signal (Zajacek, Karas, and Kunneriath 2015). Another source of the synchrotron emission is an elongated magnetosphere and tail. We investigate whether the polarized X-ray emission from the Galactic Center neutron stars will be potentially detectable in the framework of the XIPE mission. A special case is a detected young neutron star - magnetar SGRJ1745-2900 - that has undergone a series of outbursts with a peak X-ray luminosity of $5x10^{35}$ erg/s (1-10 keV; Coti Zelati, F. 2016). Apart from an intrinsic X-ray emission, the X-ray emission from magnetar outbursts may be scattered by molecular clouds in the Central Molecular Zone by Thomson scattering, which is another potential source of polarized X-ray emission for XIPE.

## SESSION 4 - X-RAY POLARIMETRY AND FUNDAMENTAL PHYSICS: QUANTUM ELECTRODYNAMICS, STRONG AND QUANTUM GRAVITY, EXOTIC PARTICLES – ORAL PRESENTATIONS

*Jeremy Heyl*

**X-ray polarimetry at the interface between astrophysics and fundamental physics**

Compact objects provide a unique environment to probe physics at the extreme from gravity to nuclear physics and plasma physics. I am going to focus on how neutron stars (and white dwarfs and black holes as well!) can help us probe quantum electrodynamics in a regime that hasn't yet been tested. I will outline how to perform calculations in non-perturbative QED and how observations of the polarization of x-rays from compact objects probes the non-linearity of the QED vacuum.

*Giorgio Matt*

**Overview of the science case of WG 4 - Part I**

X-ray polarimetry is a powerful tool to study the behaviour of matter and the transfer of radiation in extreme magnetic and gravitational fields. In particular, it promises to reveal for the first time a vacuum birefringence effect in strong magnetic fields (a QED effect predicted 80 years ago and never verified experimentally), and to provide a tool to measure the black hole spin in Galactic Black Hole binary systems in high state, to complement spectroscopy and timing measurements. In this talk I will discuss - thanks to the work done by WG 4.1 and 4.2 - the XIPE observational perspectives in these fields.

*Enrico Costa*

**Overview of the science case of WG 4 - Part II**

Gambini and Pullin proposed in 1998 that in the frame of Loop Quantum Gravity (LOG) the vacuum could exhibit deviations from non dispersiveness and a difference in the speed of light for the two states of circular polarization. This would result in a on the rotation of the plane of linear polarization of far away sources proportional to the distance and to the square (or higher power) of the energy. Many observations have been used to derive upper limits on the coupling constant. A review and a criticism of such observations may be of interest also to evaluate what more or more robust XIPE can do (WG 3.4). Also, the non-uniqueness of this approach within LQG theory should be outlined.

Another issue (WG 4.4) is the prediction of possible effects on the polarization of sources of axion photon oscillations in ordered magnetic fields. Some calculations (performed for GRBs) suggest that the effect of photon ALP oscillations in intercluster magnetic fields, (if organized in large scale domains), could produce observable effects in steady sources. We selected a number of clusters, that should be (almost) totally unpolarized, and try to evaluate which polarization can be introduced by axion photon mixing. A less straightforward approach is to search for evidence of the same effects on polarization for sources for which we can reasonably expect a polarization. This could be reduced by photon-ALP oscillations in the intercluster medium. (Of course to disentangle the effects of long distance propagation we should have a reasonable prediction of the polarization of the source in its frame and this is unavoidably based on a large amount of conjecture. We should think more about the effects of distance on correlation of polarization angles in the optical and X-ray bands). Of course effects of the mixing could be observable on sources with stronger local magnetic fields. We should discuss how these effects can be disentangled from other effects, primarily those of QED.

## SESSION 4 - X-RAY POLARIMETRY AND FUNDAMENTAL PHYSICS: QUANTUM ELECTRODYNAMICS, STRONG AND QUANTUM GRAVITY, EXOTIC PARTICLES – POSTER PRESENTATIONS

*Luigi Foschini*

**Quantum gravity studies with XIPE**

We review how polarization measurements could be useful in constraining quantum gravity theories and how XIPE could improve our knowledge in this research field.

## FINAL SESSION – SIMULATIONS, OTHER PROJECTS IN X-RAY POLARIMETRY AND CONCLUSIONS – ORAL PRESENTATIONS

*M. Pesce-Rollins (invited)*

**XIPE Simulation tools**

XIPE, if selected, will allow us to open a yet unexplored observational window measuring polarization degree and angle for hundreds of sources. To fully understand the scientific capabilities of XIPE it is imperative to perform simulation studies to assess the feasibility of a given observation. In this contribution we shall give a brief overview of the XIPE simulation tools currently available focusing on a new simulation framework, XIMPOL. Designed to produce fast and yet realistic observation-simulations, XIMPOL has the capability of producing output files that can be directly fed into the standard visualization and analysis tools used by the X-ray community, including XSPEC – which make it a useful tool not only for simulating observations of astronomical sources, but also to develop and test end-to-end analysis chains. We will present a few case studies to illustrate the scientific potential of XIPE.

*Luca Baldini*

**XIMPOL: an X-ray polarimetry observation-simulation and analysis framework**

XIMPOL is a simulation and analysis framework based on the Python programming language and the Scipy stack specifically developed for X-ray polarimetric applications. The main purpose of the package is to produce fast observation-simulations of specific regions of interest, given as basic inputs: (i) an arbitrary source model including morphological, temporal, spectral and polarimetric information, and (ii) the response functions of the detector under study, i.e., the effective area, the energy dispersion, the point-spread function and the modulation factor. In this contribution we provide a technical overview of the package, illustrating its main features, the basic design choices and its range of applicability and limitations. The main purpose of the presentation is to foster discussion and collaboration on practical applications to physically-motivated models, as well as to sketch a number of possible ways in which additional people can actively contribute to the development of the framework.

*Herman Marshall*

**Soft X-ray Polarimetry to Complement XIPE**

We present a design for a telescope to measure linear X-ray polarization over the 0.2-0.8 keV band that could complement XIPE by extending the spectral range of polarization measurements. We employ multilayer-coated mirrors as Bragg reflectors at the Brewster angle. By matching to the dispersion of a spectrometer, one may take advantage of high multilayer reactivities and achieve polarization modulation factors over 95%. The design can be used for suborbital or orbital missions. An orbital version could measure the polarizations of isolated cool neutron stars, active galactic nuclei, blazars, and jets from Galactic X-ray transients such as XTE J1118+480. Demonstration of the components is ongoing under NASA grants.

## FINAL SESSION – SIMULATIONS, OTHER PROJECTS IN X-RAY POLARIMETRY AND CONCLUSIONS – POSTER PRESENTATIONS

*Paul Connell*

### Simulating the Gas Pixel Detector of XIPE with LEPTRACK

At the University of Valencia we have developed a user friendly software package LEPTRACK to track particles in Relativistic Runaway Electron Avalanches (RREA) - thought to power Terrestrial Gamma Ray Flashes (TGFs). LEPTRACK differs from GEANT in that it is script driven and can handle particle multiplication avalanches that simply take too long or crash computer memory capacity - the user only has to specify an electric/magnetic field geometry and the input particle flux geometry - and it also has a master/deamon control system that allows parallel processing on as many CPUs as are available. To test the software we have used it to simulate the GPS on XIPE - to show the time dynamics of the scattering physics involved and the effect of polarized photons on the ionization scatter/drift pattern.

*J. Escada, B. Conceio, J. M. Maia, R. M. Curado da Silva*

### Gas mixture optimization for the GPD focal plane of the XIPE mission

In the framework of the XIPE mission [1], the photoelectric X-ray polarimeters include Gas Pixel Detectors (GPDs) composed by a Gas Electron Multiplier (GEM) and a multi-pixel anode readout. The filling gas mixture defines the ultimate intrinsic polarimetric sensitivity of the instrument, i.e. the modulation factor and the detector efficiency, which depends on the gas parameters such as: the angular differential cross-section for photoionization by polarized X-rays, the total photoionization cross-section, the photoelectron and Auger electron practical ranges, the photoelectron multiple scattering, the electron transverse diffusion and the charge gain. Various mixtures for GPDs have already been studied, either by simulation or experimentally, for X-rays energy bands of 2-8 keV and 4-30 keV. The best results point to He-DME or Ne-DME at 1 atm for 2-8 keV range and Ar/DME at 2 atm for 4-30 keV range. However, gas mixtures can be further optimized for XIPE mission [2, 3, 4]. In this work we will report simulation studies on GPD gas mixture optimization for the XIPE mission, based on a custom-made FORTRAN Monte-Carlo code [5,6]. The Monte-Carlo code includes the energy- and shell-dependent angular differential cross-sections for photoionization in the gas mixture by polarized X-rays, as well as the first order non-dipole corrections to the dipole approximation of cross-sections [7]. It records the growth of the primary electron cloud produced in the gas, reproducing in detail the X-ray photoionization and the cascade decay of the residual atomic/molecular ions (involving the emission of photoelectrons, Auger and Shake-off electrons and fluorescence X-rays), following electrons in the gas up to sub-ionization energies and during they transport by a week electric field in the drift region. Also, the absorption of polarized X-rays along the conversion/drift region of the detector will be considered. The best gaseous mixture solution will allow for an accurate reconstruction of photoelectron emission direction and therefore a higher modulation factor, allowing better degree and angle of polarization determination. Noble gases like He or Ne as well as quenching additive gases like DME and iso-C4H10 gases will be studied.

[1] P. Soffitta, et al., XIPE: the X-ray Imaging Polarimetry Explorer, Exp. Astron. vol. 36, no. 3, pp. 523-567, 2013.

[2] Ronaldo Bellazzini et al., Photoelectric X-ray Polarimetry with Gas Pixel Detectors, Nucl. Instr. and Meth. A, vol. 720, pp. 173-177, 2013.

[3] F. Muleri, et al., Low energy polarization sensitivity of the Gas Pixel Detector, Nucl. Instr. and Meth. A, vol. 584, pp. 149-159, 2008.

[4] L. Pacciani et al., The sensitivity of a photoelectric X-ray polarimeter for Astronomy: The impact of gas mixture and pressure, Proc. SPIE, vol. 4843, pp. 394-405, 2003.

[5] T. H. V. T. Dias et al., "Monte Carlo simulation of x-ray absorption and electron drift in gaseous xenon", Phys. Rev. A, vol. 48, no. 4, pp. 2887-2902, 1993.

[6] T. H. V. T. Dias et al., "Full-energy absorption of x-ray energies near the Xe L- and K-photoionization thresholds in xenon gas detectors: simulation and experimental results", J. Appl. Phys., vol. 8, pp. 2742-2753, 1997.

[7] A. Derevianko and W. R. Johnson, "Non-dipole effects in photoelectron angular distributions for rare gas atoms", At. Data Nucl. Data Tables, vol. 73, pp. 153-211, 1999.

*Niccolo Di Lalla, Enrico Costa, Melissa Pesce-Rollins, Nicola Omodei, Luca Baldini*

**A Chandra-to-XIPE converter to assess the XIPE sensitivity for extended sources**

We present a new tool, developed within the XIMPOL simulation framework, designed to convert a Chandra observation into a realistic XIPE observation-simulation. The Chandra-to-XIPE converter takes as input a Chandra event list FITS file, that includes all energetic and spatial informations about photons, and an arbitrary polarimetric source model. The effective areas of the two instruments are opportunely combined to rescale the number of events whereas other response functions of the XIPE detector are used to smear the measured energies and the reconstructed directions. Moreover this software has the capability of producing output files that can be directly inserted into the XIMPOL simulation chain, which make it a useful tool for sensitivity studies, especially for extended sources.