ABSTRACTS OF ACTUAL PROJECTS

EXPLORATORY PROJECTS

ABSTRACT WP E53:

GEOPHYSICS AND GRAVITATIONAL WAVE DETECTORS

WP Leader: Matteo BARSUGLIA, Astroparticule et Cosmologie, barsu@apc.in2p3.fr

We are investigating the different aspects of the detection of the prompt gravity perturbation due to an earthquake. The main interest of this study is to assess the feasibility of an earthquake early-warning system based on gravity and then much faster than conventional ones.

ABSTRACT WP E5:

NUMERICAL OBSERVATORY OF VIOLENT ACCRETING SYSTEMS

WP Leader: Fabien CASSE, Astroparticule et Cosmologie, fcasse@apc.univ-paris7.fr

Over the last four years, we have managed to develop a new general relativistic (GR) fluid code aiming at studying behavior of plasmas prone to extreme gravitational fields, namely in the vicinity of any kind of compact objects, and fully coupled it with ray-tracing to get spectral and timing synthetic observations. The numerical progress we made during the first years have opened the door to new astrophysical fluid studies while we carry on efforts in data processing in order to access the physical conditions prevailing in accretion flows orbiting around compact objects. It is noteworthy that we are now harvesting scientific results as the number of refereed papers stemming from WP NOVAs has reached 23 over the last 4 years. The main results of this WP focus on the variability from compact objects, in particular the Quasi-Periodic Oscillations, that are detected in the Power Density Spectrum. We have two models that cater to the low-frequency and high-frequency QPOs observed in those sources and using simulations, numerical models combined with ray-tracing we are using those QPO to infer what is happening in the source.

ABSTRACT WP E8:

MODIFIED GRAVITY FROM THE EARTH'S OUTSKIRTS TO THE COSMOS

WP Leader: Joël BERGE, ONERA, joel.berge@onera.fr

The WP E8 aims to investigate how we can test gravity from small to large scale, from the points of view of the instrumentation, data analysis and fundamental physics. With MICROSCOPE now flying, we were able to provide new constraints on the existence of a light dilaton. We also investigated how we can model transient (instead of removing them), which will allow us to properly correct for them and get a better glimpse on the instrument's transfer

function. Finally, we are currently working on a numerical model of the ISLAND torsion pendulum, with ISLAND aiming to test the inverse square law at small and planetary scales.

ABSTRACT WP E9:

LOW ENERGY ASTROPHYSICS WITH KM3NET (LEAK)

WP Leader: Alexis COLEIRO, Astroparticule et Cosmologie, coleiro@apc.in2p3.fr

Although multi-wavelength observations of core-collapse supernovae (CCSN) are now routinely performed, specific features of the gravitational collapse can only be diagnosed by neutrinos. The objective of this exploratory project is to bring together experts in CCSN physics and members of the KM3NeT collaboration to assess the capability of the KM3NeT neutrino telescopes (optimized for GeV-PeV neutrinos) to detect MeV neutrino signal from the next close-by CCSN. Using state-of-the-art numerical simulations and theoretical developments, a full Monte-Carlo simulation of the KM3NeT detectors in the MeV energy range has been implemented for the first time in 2017, as part of this exploratory project. We are now in a good position to start an accurate study of the capabilities of KM3NeT to detect a CCSN signal, and derive observational signatures imprinted in the neutrino lightcurve and/or neutrino spectrum that could be detected with those next-generation neutrino telescopes.

FRONTIER PROJECTS

ABSTRACT WP FRONTIER F1A:

EARTH AS A LIVING PLANET: FROM EARLY AGES TO PRESENT DYNAMICS

WP Leader: Pascal PHILIPPOT, Institut de Physique du Globe de Paris, philippot@ipgp.fr

The objective of the WP F1-1 is to move forward our understanding on the mechanisms, causes and consequences of the rise of atmospheric oxygen on Earth. Our aim is to characterize the evolving biosphere and the changing environments (glaciogenic events) across the 2.45 to 2.2 Ga old Great Oxidation Event. To achieve this goal, we obtained pristine drill cores of key sedimentary successions from the Turee Creek Group in Western Australia and develop new means to image and analyze chemical (major and trace elements) and isotope proxies (S, C, N, Fe, Mo, Cr) on the same samples at multiple scales (from the microfossil-scale to the sedimentary basin level). The strong focus of linking multiple scales of observations, sedimentary history, and the use of state-of-the-art mineralogical and geochemical techniques allowed identifying key insights into the history of life and oxygen during the Archean-Paleoproterozoic transition.

ABSTRACT WP FRONTIER F1B:

SUBDUCTION

WP Leader: Nicolai SHAPIRO, Institut de Physique du Globe de Paris, nshapiro@ipgp.fr

A full understanding of the subduction process and of its role in the Earth's evolution requires studying the interplay between different involved physical and chemical processes with complementary contributions from different geosciences disciplines (seismology, geodynamics, tectonics, volcanology, geochemistry ...). While many of Solid Earth geoscientists are dealing with some aspects of the subduction, most of existing studies are carried out in a frame of a single discipline and complex approaches to subduction are rare. A unique example of such a complex approach is the NSF-funded program GeoPRISMS (Geodynamic Processes at Rifting and Subducting Margins), while similar initiatives do not exist in Europe or in France. At the same time, the institutions involved in the LabeEx UnivEarthS and in particular the IPGP regroup specialists from a large spectrum of disciplines working on the subduction, providing us with a unique opportunity to take a leadership role in this area. Therefore, the main goal of the proposed workpackage is to develop an interaction between these different disciplinary teams and to create a group focusing on complex studies of the subduction processes.

ABSTRACT WP FRONTIER F2:

FROM BIG BANG TO THE FUTURE OF THE UNIVERSE

WP Leader: Yannick GIRAUD-HERAUD, Astroparticule et Cosmologie, Yannick.Giraud-Heraud@apc.univ-paris-diderot.fr

The goal of this WP is to give to the Labex team, working in cosmology, some specific help to strengthen their contributions in the major international observational projects of the domain. This has been developed along two principal axes: detector development for B-mode polarization of the CMB experiments and both data analysis and theoretical development to study the nature of Dark Energy in the forthcoming galaxy survey projects. The contribution of the labex has been crucial to structure the labex team for preparing the forthcoming years in these fields with, mainly since last year, an emphasis to consolidate a major contributor of the French community to three CMB projects : QUBIC (as the vector of a new instrumental concept - the bolometric interferometry), LiteBIRD (today, the only CMB-B polarisation Space project supported by an space agency) and POLARBEAR/Simons Observatory (for which we are building today what we certainly be the main French participation to the US CMB-S4 program). Concerning the Dark Energy aspects, the goal is to develop joint analysis techniques that will improve cosmological constraints using existing datasets (legacy Planck data, SDSS data, HST legacy data, CFHT, DES and HSC public data...), and on the longer term to prepare for joint analyses of the next generation optical and CMB surveys (which includes LSST, Euclid, DESI, WFIRST as well as CMB S4 - and its precusors like QUBIC

and Simons Observatory). In both cases, the aspects related to space projects are undertaken in close contact with the « FACe » and « University Paris Diderot Campus Spatial ».

ABSTRACT WP FRONTIER F2A:

SUPPORT TO PCCP

WP Leader: Stavros KATSANEVAS, Astroparticule et Cosmologie, katsan@apc.in2p3.fr

The Paris Centre for Cosmological Physics is a place of research, education and scientific exchanges in the field of cosmology, or more generally the physics of the Universe. We report on the education (MOOC Gravity and Teaching the Universe), research (in particular on cosmology and gravitational waves, start of the work on WP V3) and art and science (Univers 2.à) activities.

ABSTRACT WP FRONTIER F3:

THE TRANSIENT CATASTROPHIC UNIVERSE

WP Leader: Stéphane CORBEL, AIM/CEA, stephane.corbel@cea.fr

Project Frontier #3 targets the unbiased physical study of catastrophic Universe events through their multi-wavelength transient signatures (from low frequency radio to high energy gamma rays). On one hand, the expertise of the scientific members of the project is mandatory to constrain the in-situ physics (notably, of microquasars and the interaction between their accretion disk and jets at their various spectral states). On the other hand, we are applying cutting-edge sparse signal/image reconstruction methodologies by combining the expertise and the tools of CosmoStat laboratory and the current tools developed for large-scale instruments such as LOFAR and SKA.

INTERFACE PROJECTS

ABSTRACT WP I2:

GEOPARTICLES

WP Leader: Alessandra TONAZZO, Astroparticule et Cosmologie, tonazzo@in2p3.fr

After establishing techniques to use elementary particles to explore the Earth and its structure, WP I2 is focusing on a novel application to archaeology. Cosmic muons that traversed a structure can provide information on its internal structure in a non-destructive way. The feasibility of using this method to explore the interior of Macedonian tumuli has been assessed

with simulation studies. A measurement campaign on the Apollonia archaeological site in Greece is foreseen.

ABSTRACT WP 13:

FUNDAMENTAL PHYSICS AND GEOPHYSICS IN SPACE

WP Leader: Hubert HALLOIN, Astroparticule et Cosmologie, hubert.halloin@apc.univ-paris7.fr

This work package is a joint project between APC and IPGP, on the LISA Pathfinder and LISA missions, as well as the development of a novel optical readout system for planetary seismometers. Most of the work on LISA Pathfinder ended with the decommissioning of the mission in July 2017. The LabEx supported the PhD thesis and afterwards first year of post-doc of H. Inchauspe who worked on the modeling of LISA dynamics (based on LISA Pathfinder experience) and initiated the characterization method of cold gas thrusters. Following the selection of LISA by ESA, the dynamics simulation method is now being included into an 'end-to-end' science simulator of the mission, where APC has a leading role. Concerning the optical readout system, L. Fayon (3rd year PhD student on USPC grant) performed extensive simulation and noise level estimation. The cavity and mirrors have been designed and manufactured. Lucile is currently working on the tuning the cavity on the resonant frequency. She also worked on the response function modeling for the leveling system of SEIS seismometer onboard Insight in order to estimate its capability to measure subsurface waves.

ABSTRACT WP 16:

DUST TO PLANETS

WP Leader: Sebastien RODRIGUEZ, Institut de Physique du Globe de Paris, rodriguez@ipgp.fr

Our project aims at studying the differentiation and surface dynamics of planets and, starting 2018, will focus on Earth, Mars and Titan. Theme 1 will combine high P/T experiments and isotopes geochemistry to understand the fate of volatile elements during planetary formation. Theme 2 will develop theoretical tools to probe the internal structure of planets using seismology and prepare the incoming landing on Mars of the INSIGHT mission. Theme 3 will focus on large-scale dune experiments and global scale study of Mars and Titan deserts, with collaboration with theme 2, to understand planetary surface and regolith properties and dynamics.

ABSTRACT WP 17:

GAMMA-RAY BURSTS: A UNIQUE LABORATORY FOR MODERN ASTROPHYSICS

WP Leader: Diego GÖTZ, AIM/CEA, diego.gotz@cea.fr

The goal of the WP 7 Interface project was to prosecute our studies on Gamma-Ray Bursts (GRB) on two main subjects: on one side as potential and promising sources of gravitational waves, neutrinos, cosmic rays, and TeV gamma-rays, and on the other side on the observations and interpretation of data about the GRB environment. On the GRB environment side we managed to produce two first author papers thanks to the hiring by the LabEx of M. Arabsalmani. One paper deals with the countent of molecular gas in GRB host galaxies end the second one with metallicities and stellar mass contents of GRB host galaxies. On the GRB-multi-messenger connection, August 17th 2017 marked a fundamental date in modern physics with the first simultaneous detection of a gravitational wave source with short gamma-ray burst. We are involved in follow-up studies, and plan to play a more important role in the years to come.

ABSTRACT WP 18:

ARGOS: ASTROPARTICLE RESEARCH, GEOLOGY & OCEANOGRAPHY STUDIES

WP Leader: Véronique VAN ELEWYCK, Astroparticule et Cosmologie, elewyck@apc.univ-paris7.fr

The KM3NeT Collaboration has started the deployment of a next-generation neutrino telescope on two abyssal sites in the Mediterranean Sea, close to Toulon (France) and Capo Passero (Sicily). This provides new scientific and technological opportunities for interdisciplinary collaborations with Earth and Sea Sciences. The ARGOS project and aims at federating the available expertise at APC and IPGP, to exploit the unique abyssal location and infrastructure of KM3NeT for the deployment and exploitation of seismic and marine sensors and for the study of the composition of the inner Earth (mantle and core) through atmospheric neutrino oscillation tomography.

ABSTRACT WP 19:

SOLAR GEOMAG

WP Leader: Alexandre FOURNIER, Institut de Physique du Globe de Paris, fournier@ipgp.fr

The main goal of the project SolarGeoMag is to improve our physical understanding, and our capability to predict, the long-term magnetic activity of the Sun and the Earth. This understanding will be based on the analysis of 3D simulations that will be parameterized and implemented in low dimensional models amenable to data assimilation experiments. This is of fundamental and practical interest. Two years into the project, we have at our disposal a variational assimilation tool to forecast solar activity. We have started to assimilate solar magnetograms and will take part in the next solar panel for prediction of solar cycle 25, using our physics-based approach which rests on a mean-field model of the solar dynamo. Our exploration of parameter space for 3D MHD simulations, and their subsequent analysis, is a computationally expensive task that remains to be completed.

ABSTRACT WP I10:

FROM EVOLVING BINARIES TO THE MERGING OF COMPACT OBJECTS

WP Leader: Sylvain CHATY, AIM/CEA, chaty@cea.fr

Most massive stars experience a binary interaction in the course of their life. In this AIM/APC LabEx project we look carefully at the 3 most uncertain steps concerning the evolution of stellar binaries: common envelope phase, natal kick and metallicity. By taking into account the new 6D-view (position and velocity) obtained from the Gaia satellite on binaries, we aim to better constrain their evolution towards the merging of two compact objects (binary neutron stars, binary black holes or neutron star/black hole), leading to the emission of gravitational waves.

ABSTRACT WP I11:

COR2DISC

WP Leader: Patrick HENNEBELLE, AIM/CEA, patrick.hennebelle@cea.fr

Stars form inside dense moleculcar clouds through gravitational collapse. As accretion proceeds onto the central protostars, the angular momentum carried along by the gas, leads to the formation of centrifugally supported, circumstellar and protoplanetary discs. While the understanding of disc formation and evolution has recently done important progress thanks to both high resolution observations and heavy numerical simulations, several fundamental and fascinating questions remain unknown, concerning the physics of molecular cloud collapse and the building of a planet forming cimrcumstellar disk. Study of Solar System material (isotopic composition of condrites, chemical composition of minerals) show that the Solar System material was not flly homogeneized and that possibly large scale transport may have occurred (for example high temperature minerals were found in comet's coma).In addition some material may have arrived lately (like Al26). We do not know if these large scale transport processes may have occurred during the disk phase or have occurred during the cloud collapse. The current project CORE2DISK aims to bridge the gap between the physics of the cloud collapse (using high end numerical simulations in the hydrodynamic, idela MHD and non ideal MHD approximations) as well as to understand the condensation/volatilisation and transport of material during the disk phase (using long term-large scale 1D simulation of dust transports). In September 2017, we have hired a postdoc to start working on this link. During the same year, several intensive simulations of core collapse have been lead (Hydro, ideal MHD, non ideal MHD) and are under analysis. Models of dust transport in an evolving and radiative disk have been also developped and presented in conferences. In 2018 we aim to develop a semi-analytical model of cloud collapse to bridge the two approaches, and to quantify the effect of the collapse dynamics ontp the material composition and transport in the Solar System.

ABSTRACT WP I12:

MΛΨ-P² MULTI-WAVELENGTH AND MULTI-PHYSICS PLANETARY PEELING

WP Leader: Antoine LUCAS, Institut de Physique du Globe de Paris,, lucas@ipgp.fr

Solar System exploration unveiled the ubiquity of mass wasting and sediment transport. The project aims at combining data analysis with model simulation at various scales and wavelengths, thereby allowing a quantitative assessment of the geomorphology across a wide range of planetary environments. The project contributes to help to infer geomechanical models applied to mass wasting in both surface and sub-surface properties, as well as various triggering and feedback mechanisms operating throughout the Solar System. Ultimately, this project will provide new understanding on how planetary surfaces form and evolve over time, from small bodies to icy moons and planets.

YOUNG TEAM PROJECTS

ABSTRACT WP JE2:

DIRECT SEARCHES FOR DARK MATTER WITH LIQUID ARGON DETECTORS

WP Leader: Davide FRANCO, Astroparticule et Cosmologie, dfranco@in2p3.fr

The ARIS experiment, funded by the LabEx JE2, has achieved fundamental milestones in the comprehension of liquid argon response to electron and nuclear recoils. These results will impact on the sensitivity to WIMPs of current and future dual-phase TPCs.

ABSTRACT WP JE3:

ADVANCED GAMMA-RAY SCIENCE METHODS AND TOOLS

WP Leader: Karl KOSACK, AIM/CEA, karl.kosack@cea.fr

Improvements to VHE Gamma Ray Telescope Reconstruction with advanced signal processing methods: We present the latest results from UnivEarths project JE3, where we apply novel signal processing techniques to the event reconstruction for Imaging Atmospheric Cherenkov Telescopes (IACTs). The result is a significant improvement to the point-spread-function and detection sensitivity of gamma rays in the range of 50 GeV to 100 TeV. The results are applied to simulated data for the Cherenkov Telescope Array (CTA) and imply that we can achieve a sensitivity better than the design requirements with minimal effort.

EDUCATIONAL PROJECT

ABSTRACT WP K2:

UNIVEARTHS NANOSATELLITE STUDENT (IGOSAT) PROJECT

WP Leader: Hubert HALLOIN, Astroparticule et Cosmologie, hubert.halloin@apc.univ-paris7.fr

IGOSat is an educational project aiming at developing, with students, a 3U CubeSat with 2 science payloads : a new generation of scintillation detector for electrons and gamma-rays; and a dual frequency GPS receiver for measurements of the total electronic content of the ionosphere. IGOSat started in 2012 and welcomed, up to now, about 230 students on the project, including more than 50 interns (bachelors and mostly master students). Some subsystems of IGOSat are purchased 'of-the-shelf' (e.g. the telecom and GPS boards), but the general rule is to design and build as much as possible internally. In September 2017, IGOSat passed the Critical Design Review (CDR), ending Phase C. IGOSat is therefore now on in Phase D, i.e. starting the crucial integration, tests and validation phase of the qualification and flight models. The launch is expected in 2019. IGOSat is co-funded by the LabEx and the CNES through its JANUS program. The main laboratories involved in IGOSat are the APC and the IPGP.

VALIDATION PROJECTS

ABSTRACT WP V1:

DATA DISTRIBUTION, VISUALISATION AND CLOUD COMPUTING

WP Leader: Cécile CAVET, Astroparticule et Cosmologie, ccavet@apc.in2p3.fr

The valorization project has been focusing on harmonizing the usage of the distributed data centres such as cloud infrastructures for the different projects (LISA-Pathfinder/LISA, Euclid and IPGP observatories) in order to allow an optimal usage of the resources. In addition, the different aspects of the computing needs has been investigated in view of their processing requirements. An important part of the project was the dissemination of the results on this distributed computing topics: we have realized seminar, workshops and hands-on session on IaaS cloud, container technology and Big Data framework such as Hadoop.

ABSTRACT WP V2:

IN SITU COSMOGENIC DATING OF EXTRATERRESTRIAL SURFACES

WP Leader: Manuel MOREIRA, Institut de Physique du Globe de Paris, moreira@ipgp.fr

Our project is the design of a prototype of "spatializable" mass spectrometer and its preparation line dedicated to the analysis of all noble gases, in order to estimate, by in situ measure-

ments, exposure ages of extraterrestrial samples (Mars, The Moon and asteroids). It is clear that only a small number (and mass) of samples will be returned to Earth, and therefore the careful choice of these samples, and the in situ analyses of a large number of samples will stay the better technic to answer to some simple but important scientific questions such as age surfaces, ages and frequency of impacts, or exposure duration by the solar wind.

ABSTRACT WP V3:

DETECTORS FOR THE FUTURE

WP Leader: George SMOOT, Astroparticule et Cosmlogie, gsmoot@apc.in2p3.fr

The project implements a future program of detector device and data acquisition systems that have strong potential to lead to new science capabilities and novel systems for research. We focus for the short run on cryogenic detectors of a new type and a corresponding new level data acquisition system. Our proposed specific detectors are relevant to the future of astronomy as a device that is like an improved CCD able to make images while detecting individual photons and measuring the individual photon energy to a resolution as good as 1% in the blue. The applications of this kind of detector technology are many and in particular in to Earth and Planetary Sciences, as well as medicine. We report the first results on the detector prototype and the testing system.