GdR
Ondes Gravitationnelles

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Groupement de recherche
Ondes gravitationnelles

History of the GdR

- Founded by Pierre Binetruy at the end of 2016 with IN2P3 funding
- Scientific context:
  - First direct detections of GW from BHB collisions by LIGO/Virgo
  - Flight of LISA Pathfinder and preparation of the LISA mission
  - Birth of a new science and need to form and to structure the French community
- Activities started in 2017

http://gdrgw.in2p3.fr/

Main role of the GdR

- Resemble the french scientific community with interest in GW physics: astrophysicists, theorists, experimentalists, data analysts…
- Organise meetings where to report on the latest progresses and discoveries in the field, where the community can meet and exchange, and young researchers can present their work
- Promote new collaborations and projects (the GdR is organised in Working Groups)
- The budget is devoted exclusively to meetings organisation, no research financing

Structure of the GdR

General overview

- 290 members
- 70 laboratories (some outside France, former members)
- Composition at the end of 2020 : IN2P3 100, INSU 65, INP 55, INSIS 20, INSMI 2, INS2I 4

Gouvernance

Board : 6 members

- Luc Blanchet (IAP, theory)
- CC (Direction, APC, cosmology)
- Eric Chassande-Mottin (APC, data analysis)
- Benoit Mours (IPHC, Virgo)
- Gilles Theureau (LPC2E, EPTA)
- Marta Volonteri (IAP, astrophysics, multi-messenger)

Structure of the GdR

Scientific Council : 17 members

- members of the board
- nominated members : *Matteo Barsuglia* (APC, detectors), *Sylvain Chaty* (Univ. Paris, multi-messenger astrophysics), *Joseph Martino* (APC, detectors), *Jérôme Novak* (LUTH, neutron stars), *Florent Robinet* (LAL, data analysis), *Danièle Steer* (APC, cosmology), *Filippo Vernizzi* (IPhT, modified gravity theories), *Michal Was* (LAPP, detectors)
- representatives of *Programmes Nationaux*: *Philippe Brax* (PNCG), *Patrick Charlot* (PNGRAM), *Susanna Vergani* (PNHE)

✓ Scientific decisions: themes, renewals, community needs…

✓ Working group supervision: themes, coordinators, programme, advancements…

✓ Organisation of meetings and of the annual assembly

Science of the GdR

Fundamental physics and cosmology

- GW from binaries: waveforms, propagation…
- Tests of General Relativity and of modified gravity theories: in strong field, propagation modes, exotic objects…
- cosmology: standard sirens, stochastic GW background
  ➔ *connection with CMB physics, dark matter*
- physics beyond the standard model of particle physics: symmetry breaking, string theory…
  ➔ *connection with particle physics*

Science of the GdR

Astronomy and astrophysics

- Massive BHB: population, origin, binary formation, connection with structure formation, counterparts…
- Stellar origin BHB: population, origin, binary formation…
- Neutron stars: population, equation of state, counterparts of mergers (gamma-ray bursts, kilonovae…)
  ➔ *connection with astrophysics, astroparticle physics, nuclear physics*
- Counterparts and multi-messenger: electromagnetic: optical, X/gamma-ray, radio…
  ➔ *connection with science of astronomical observatories; neutrinos observatories*
  ➔ *connection with astrophysics and fundamental physics*

Science of the GdR

Data analyisis

- Parameter estimation: matches filtering techniques, Monte Carlo
- Foreground and noise subtraction
  ➔ *connection with CMB physics*
- Analysis of un-modelled signals
- More refined techniques: machine learning
  ➔ *connection with computer science, mathematics*

Detector science

- Ground-based : LIGO/Virgo
- Space-based : (LISA Pathfinder) LISA
- Future : cryogenic on ground (ET), atom interferometry…

Connection with (astro)physical observatories and big infrastructures

- Astronomical surveys (radio, optique, X-ray, gamma-ray…)
- Cosmological surveys
- Neutrino detectors
- CMB detectors (ground and space)
- LHC for EW physics

GdR working groups

- Waveforms (63 members)
  coordinators : Luc Blanchet, Guillaume Faye, Eric Gourgoulhon, Alexandre Le Tiec
  - MBHB, stellar origin BHB, NSB et WDB
  - Numerical relativity (BHB, relativistic hydrodynamics…)
  - Analytical methods (PN, EoB, Phenom, effective field theories…)

- Sources populations (66 members)
  coordinators : Stas Babak, Irina Dvorkin, Astrid Lamberts, Gilles Theureau
  - Binaries origin and formation (MBHB, stellar origin BHB, IMBHB…)
  - Stochastic foregrounds from binaries
  - Complementarity ground/space: multi-wavelength GW observations

GdR working groups

- Prediction and follow-up of multi-messenger signals (85 members)
  coordinators : Sylvain Chaty, Olivier Godet
  - Multi-wavelength follow-up of GW emitting events
  - Observational prediction and interpretation of the detections
  - Counterparts: NSB, MBHB, stellar origin BH-NS binaries…

- Cosmology (102 members)
  coordinators : Tania Regimbau, Danièle Steer, Vincent Vennin
  - early universe signals (stochastic backgrounds)
  - cosmological parameters (standard sirens)
  - angular correlation, large scale structure
  - Weak and strong lensing
  - Cosmic- (super-) strings
  - Primordial BHs

GdR working groups

- Neutron stars, supernovae and nucleosynthesis (76 members)
  coordinators : Anthea Fantina, Jérôme Novak
  - Internal structure and equation of state of NS
  - Heavy elements synthesis
  - supernovae

- Data Analysis (106 members)
  coordinators : Eric Chassande-Mottin, Florent Robinet
  - Data quality and noise analysis
  - parameter estimation
  - Bayesian methods
  - Un-modelled sources
  - Non-gaussianity, non-stationarity
  - Foreground subtraction
  - De-noising, machine learning

GdR working groups

- Tests of GR and of modified gravity theories (106 members)
  coordinators : Laura Bernard, Luc Blanchet, Filippo Vernizzi
  - tests of the inspiral, waveforms in GR and in alternative theories
  - physics of the horizon, tests of the no-hair theorem
  - tests of GW propagation and polarisations
  - cosmological modified gravity theories

- Detectors development (80 members)
  coordinators : Eleonora Capocasa, Walid Chaibi, Joseph Martino
  - LIGO/Virgo and LISA
  - Development of ET France from the instrumental point of view and in light of the scientific context
  - Atom interferometry: ground (MIGA, ELGAR) and space

activities in 2018-2021

Première assemblée générale : Paris, 18-19 octobre 2018

https://indico.in2p3.fr/e/GdROG

98 participants

Building the GdR community, creating contacts between theorists and experimentalists, meeting, discussing, presenting the last advancements in the field

- Assembly of presentation of the GdR
- 1 hour per working group: invited seminars to give an overview of the subject + discussion
- General discussion: presentation of LISA France (I. Petibon), summary of GdR activities of the year

activities in 2018-2021

Deuxième assemblée générale : Lyon, 10-11 octobre 2019

https://indico.in2p3.fr/e/GdRAssembleeLyon

76 participants

Building the GdR community, … + provide an event in which young researchers can present their work

- Invited seminars on the latest progresses:
  - LIGO/Virgo catalogues (E. Porter)
  - Open data (F. Marion)
  - Present and future multi-messenger (M. Habouzit)
  - Future detectors and French contribution (M. Barsuglia)
  - presentation of IPNL/LMA (J. Degallaix et al)
- 1 hour per working group: contributed seminars + discussion
- General discussion: ET and 3g science, activity/structure of the GdR

activities in 2018-2021

Troisième assemblée générale : on line, 14-15 octobre 2020

https://indico.in2p3.fr/event/20835/

140 participants

- Invited seminars on the latest progresses
  - O3 results (B. Mours)
  - Their implications (T. Dal Canton)
  - H0 measurement (M. Rigault),
  - 25 years of PTA (S. Chen)
  - NS equation of state (F. Gulminelli)
  - Overview of future GW science (N. Christensen)
- 1 hour per working group: contributed seminars + discussion
- General discussion: future GW science + in2p3 perspective, activity/structure of the GdR

activities in 2018-2021

"Gravitational waves: a new messenger to explore the universe"

Six-weeks thematic programme at the
Centre Emile Borel de l'Institut Henri Poincaré
1 mars - 9 april 2021

Organisation: C.C., E. Chassande-Mottin, G. Faye,F. Vernizzi, M. Volonteri

Structure of the thematic programme

- Theoretical aspects of gravitational-wave science (March 1-12)
- Astrophysics and cosmology (March 15-26)
- Gravitational-wave detectors and data analysis (March 29-April 9)

activities in 2018-2021

Structure of the thematic programme

LECTURES

Gravitational waveforms: Alessandra Buonanno
Testing gravitational theories: Shinji Mukoyhama
GW detectors: David Shoemaker
GW data analysis: Neil Cornish
(Massive) black hole binaries: Monica Colpi
Multimessanger astrophysics: Giancarlo Ghirlanda
GWs and cosmology: Danièle Steer
Hydrodynamique relativiste: Luciano Rezzolla
Méthode d'expansion post-Newtonienne: Luc Blanchet

INTERDISCIPLINARY SEMINARS

Introduction to astrophysical observations: Susanna Vergani
Machine Learning for detectors and data analysis: Gabriele Vajente
Stochastic backgrounds: Germano Nardini

activities in 2018-2021

Structure of the thematic programme

INVITED SEMINARS

Claudia De Rham (Imperial College); Eleonora Capocasa (U Tokyo); Arianna Renzini (Imperial College London); Valerie Domcke (DESY Hamburg); Gabriele Vajente (Caltech LIGO); Alberto Sesana (Univ. Milano); Swetha Bhagwat (Syracuse University); Gabriele Gonzales (Louisiana State University); Katerina Chatziioannou (Flatiron Institute), Chris Messenger (Univ. Glasgow); Daniel Holz (Univ. Chicago); Tania Hinderer; Elena Maria Rossi; Richard O'Shaughnessy; Misao Sasaki; David Kosower; Antonio Riotto; Eleonora Capocasa; Edward Porter; Matias Zaldarriaga

activities in 2018-2021

Quatrième assemblée générale : on line, 30 mars -1 avril 2020

https://indico.math.cnrs.fr/event/5766/overview

272 participants

- This occurred in the context of the IHP thematic programme: the assembly took advantage of the participants to the programme, the attendance was international and the meeting provided an extensive overview of the world research in GW science
- 21 invited speakers from the IHP programme
- 37 contributed seminars

activities in 2018-2021

Cinquième assemblée générale : Annecy, 11 -12 October 2021

https://indico.in2p3.fr/event/24548/

55 registrants for the moment

- Two invited seminars:
  - Viola Sordini on O3 results
  - Stas Babak on PTA results
- Contributed seminars
- 1 hour discussion on the renewal of the GdR

We still have availability: submit your talk and come to Annecy!

activities in 2018-2021

Working Groups meetings

- *Développement des détecteurs* : Paris, juin 2018 ; Paris, juin 2019 ; en ligne avr 2021

- *Analyse des données* :
  - réunion jointe avec le GdT "Méthodes d'Analyse des Données" du GdR ISIS de l'INS2I (Information, Signal, Image, Vision), Paris oct 2018
  - “Gravitational wave open-data workshop”, Paris avril 2019
  - en ligne, nov 2020

- *Etoiles à neutrons* :
  - Paris, mai 2019
  - réunion jointe avec le GdT "Astrophysique nucléaire" du GdR RESANET (physique nucléaire), Paris sep 2018 ; en ligne, juin 2020

activities in 2018-2021

Working Groups meetings

- *Cosmologie* : Paris, nov 2019 ; on line, jan 2021
- *Tests de la relativité générale et théories alternatives* : Gif-sur-Yvette, jan 2019
- *Formes d'ondes :* Meudon, mai 2019
- réunion jointe, *Tests de la relativité générale et théories alternatives + formes d'ondes :* Paris, fév 2020
- réunion jointe, *Population des sources et prédiction et suivi des signaux multi-messager* : mars 2021
- organisation de deux ateliers aux journées de la Société Française d'Astronomie et Astrophysique, 2018 et 2019

Support to the community / News / Highlights

- The GdR allowed a new community to form, federate and strengthen
- The GdR meetings and assemblies allowed dozens of students and postdocs to present their work to the national community
- We provided support to the ET project
- We managed to maintain a regular activity during the pandemic
- The GdR expires at the end of the year: very positive outcome and evaluation by IN2P3
- The connection with the astrophysics community needs to be reinforced, in particular in what concerns the multi-messenger aspects but also at the level of sources populations
- New edition of the GdR: new director Danièle Steer, vice-director Filippo Vernizzi, board + scientific council + WGs

Thank you for your attention

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