

# MODE workshop, Meudon, 16/11-20/11

## 1 Summary

Over the last decade an enormous amount of new information about neutron stars has been accumulated by the satellites like XMM-NEWTON, CHANDRA, INTEGRAL, FERMI, and the earth laboratories, in particular the different radio-telescopes, but also the HESS observatory. Moreover, very interesting informations are expected to shed light on compact stars in the near future thanks to the gravitational-wave detectors like VIRGO and LIGO. Various new phenomenons related for instance to the enormous magnetic fields (Flares and QPO), to the reheating of the crust or to pulsar wind nebulae in supernovae remnants have been observed. A thorough understanding of all these phenomena requires to bring together leading and promising young researchers from all the fields. Important issues to address include : What can we learn from these new observations about neutron star structure and the radiation mechanism ? Which models shall be developed to analyze the new data ? What would be key observations for the future ? The aim of th workshop was to help the three communities to exchange with each other as well as discussing internal advanced issues.

## 2 Scientific content

Since the revolutionary discovery of a first radio pulsar by Jocelyn Bell Burnell and Anthony Hewish (Nobel prize in 1974), almost 2000 neutron stars have been detected as radio pulsars. Today we see a large amount of new interesting data from recently launched satellites sensitive to X and gamma rays arriving. In particular, the detection of several gamma ray pulsars by the satellite Fermi will help to understand the emission process of high energy radiation and the geometry of the beam. In this way, we find the following classes of interesting objects : CCOs (Compact Central Object), DINSs (X-ray Dim Isolated Neutron Stars), AXPs (Anomalous X-ray Pulsars), SGRs (Soft Gamma Repeaters), LMXBs (Low-Mass X-ray Binaries), HMXBs (High Mass X-ray Binaries), SXR (Soft-X-ray Transients) etc... and recently in addition the RRATs (Rotating RADIO Transients, McLaughlin et al 2005), intermittent pulsars (M.Kramer et al 2007), or the numerous “radio-quiet” gamma-ray pulsars discovered by Fermi (Abdo et al 2009).

Besides, the exciting discovery in 2005 of the binary pulsar system J0737-3039 offers, as the Hulse-Taylor pulsar discovered in 1974, a fantastic laboratory to test general relativity. These new discoveries are the consequence of the intensification of observations and the improvement of terrestrial and spatial instruments. In addition they result from the confrontation of different view-points, on the one hand theoretic (emission mechanisms, inner structure, equation of state, gravitation,...) and on the other hand observational (multi wave-length analysis, gravitational wave detectors,...). This has allowed to study new phenomena, such as for example the pulsar precession or quasi periodic oscillations in SGR. From a more fundamental point of view, the phenomena related to neutron stars represent nowadays a unique laboratory for testing matter under extreme conditions. In order to cope with the challenge of understanding this huge amount of new information, a common effort of theoreticians and observers is necessary.

Thus, the aim of the workshop has been to put together observers and theoreticians and to provide the environment to favor discussions. To that end the program contained review and

short talks and three long tutorials on one subject of each community. The sessions have been arranged around the following topics :

- Radio timing, rotating neutron stars,
- General relativity and neutron star modeling,
- Nuclear physics issues and equation of state,
- Observation at different wave lengths,
- Emission processes and supernovae,
- Supernovae remnants and pulsar wind nebulae.

### **3 Impact of the event**

The workshop has to be seen as a first attempt to encourage discussions and to build up relations between the different communities which is not always evident. A particular question arising during the workshop was whether it is possible to obtain information about the central object or the supernova explosion mechanism from the observation of pulsar wind nebula and supernova remnants. During the discussion, some interesting points arised, for example on the moment of inertia of the central object, which have to be investigated further. The search for submillisecond pulsars in the view of constraining the equation of state from rapidly rotating neutron stars seems very promising, too. Concrete collaborations has been initiated during the workshop, such as one aiming at finding submillisecond pulsars in the view of constraining the equation of state, or another collaboration focusing on increasing the number of recorded thermal relaxing LMXRT to extract properties of the crust. In conclusion, the first contact has been established and future editions of the workshop seem very promising for further advances.

### **4 Final programme**

#### **Monday afternoon : 14 :00 - 18 :00**

- 14 :00-14 :40 Isaac Vidaa : Symmetry energy, neutron star crust and neutron skin
- 14 :40-15 :10 Alexandre Santos : Isospin Constraints on the Parametric Coupling Model for Nuclear Matter
- 15 :10-15 :40 Coffee break
- 15 :40-16 :20 Marek Abramowicz : New models of slim disks in Kerr
- 16 :20-16 :50 Vittorio Soma : Spinodal instability in nuclear matter
- 16 :50-17 :20 Camille Ducon : Collective modes with pairing in the outer core of neutron stars
- 17 :20-18 :00 Discussion

#### **Tuesday morning : 10 :00-12 :30**

- 10 :00-10 :40 V. Beskin : Limiting polarization - missing link in the theory of the pulsar radio emission
- 10 :40-11 :10 Coffee break
- 11 :10-11 :50 Fiorella Burgio : Protoneutron stars in the BHF many-body theory
- 11 :50-12 :30 David Blaschke : Recent trends in the high-density EoS

## **Tuesday afternoon : 14 :00-18 :00**

- 14 :00-14 :40 Michal Bejger : On the approximation of the Keplerian frequency of neutron stars
- 14 :40-15 :10 Andrea Passamonti : Hydrodynamics of Pulsar Glitches
- 15 :10-15 :40 Coffee break
- 15 :40-16 :40 David Smith : Results from Fermi
- 16 :40-18 :00 Discussion

## **Wednesday morning : 09 :00-12 :40**

- 09 :30-10 :10 Elena Amato : Multi-wavelength observations of Pulsar Wind Nebulae
- 10 :10-10 :40 Marie-Helene Grondin : Fermi-LAT observations of Pulsar Wind Nebulae
- 10 :40-11 :10 Matthieu Renaud : HESS observations of Pulsar Wind Nebulae
- 11 :10-11 :40 Coffee break
- 11 :40-12 :10 Rgis Terrier : On the large scale nebula of PSR B1706-44
- 12 :10-12 :40 Anna Zaczek : Taking a look at the Pulsar Wind Nebula G21.5-0.9 in the near infrared

## **Wednesday afternoon : 14 :00-**

- 14 :00-15 :00 Robert Ferdman : Radio timing and Tempo2
- 15 :00-15 :30 Coffee break
- 15 :30-16 :30 Jrme Margueron : Neutron star cooling
- 16 :30-17 :30 Marianne Lemoine-Goumard : Fermi data analysis
- 17 :30-18 :30 Discussion
- 18 :30 Buffet

## **Thursday morning : 09 :30-12 :40**

- 09 :30-10 :00 Natalie Webb : Detection of High-Energy Gamma-Ray Emission from the Globular Cluster 47 Tucanae with Fermi
- 10 :00-10 :30 Benot Pancrazi : High energy observations of millisecond pulsars - understanding the fundamental parameters through modelling of the X-ray lightcurve
- 10 :30-11 :00 Coffee break
- 11 :00-11 :40 Armen Sedrakian : Quark matter equation of state
- 10 :50-11 :20 Patrick Blottiau : Comparative role of Standing Accretion Shock Instability and microphysics in the success of Type-II supernova explosions
- 12 :10-12 :40 Anthea Fantina : Type-II Supernov : study of electro-weak processes during core collapse phase

## **Thursday afternoon :14 :00-17 :40**

- 14 :00-14 :40 Damiano Caprioli : Multi-wavelength observations of SNRs
- 14 :40-15 :10 Jean Ballet : The Fermi 1st year catalog and its related SNRs
- 15 :10-15 :40 Coffee break

- 15 :40-16 :10 Fabio Mattana : Identification of extended hard X-ray emission in the Vela-X pulsar wind nebula
- 16 :10-16 :40 Vincent Marandon (30min) : Observation of the Very Dark Source HESS J1858+020
- 16 :40-17 :10 Nukri Komin : H.E.S.S. observations of the LMC
- 17 :10-17 :40 Rgis Terrier : GeV emission from the shell type SNR Cygnus Loop

**Friday morning : 09 :30-13 :00**

- 09 :30-10 :00 Anne Decourchelle : X-ray observations of supernova remnants
- 10 :00-10 :30 Yves Gallant : TeV gamma-ray observations of SNRs (and superbubbles) and implications
- 10 :30-11 :00 Jean-Marc Casandjian : Diffuse galactic background as seen by Fermi
- 11 :00-11 :30 Coffee break
- 11 :30-12 :00 Gilles Ferrand : 3D simulations of supernova remnants evolution including non-linear particle acceleration
- 12 :00-12 :30 Stefano Gabici : Broad-band non-thermal emission from molecular clouds illuminated by cosmic rays from nearby supernova remnants
- 12 :30-13 :00 Fabien Casse : Postshock turbulence in young supernova remnants