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## 2nd European Frequency and Time Seminar

EFTS 2014

<http://efts.eu>

Dates & place:

From Monday, June 30 to Friday, July 4 juillet 2014 (5 days)

Organised by: Département Temps-Fréquence (DTF) - FEMTO-ST Institute

CNRS UMR 6174 <http://www.femto-st.fr>

The EFTS is hosted by:

École Nationale Supérieure d'Ingénieurs de Mécanique et des Microtechniques

ENSMM <http://www.ens2m.fr>

26, Rue de l'Épitaphe

CS 51813

25030 BESANÇON CEDEX

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## EFTS2014 DETAILED PROGRAMME

### 1 Lectures & Seminars

Total duration of lectures & seminars : 23 hours.

#### 1.1 Introduction to Time & Frequency

Monday June 30 from 9h50 to 10h40 - Noël Dimarcq - CNRS-LNE-SYRTE (F)

#### 1.2 Oscillator Primer

Monday June 30 from 11h10 to 12h00 - Jean-Pierre Aubry - consultant (F)

Introduction - T&F generalities - Oscillator applications, performances / domain - Noise in oscillators - Environmental sensitivities - Oscillators hierarchy - Trends and evolution - Conclusions

#### 1.3 The Measurement of Phase Noise $S_{\phi}$

Monday June 30 from 12h00 to 12h50 - Enrico Rubiola - FEMTO-ST (F)

Basic concepts - Phase noise measurement methods - The measurement of oscillators - The Cross-Spectrum method - Noise in amplifiers and components - Amplitude noise

## **1.4 Time Domain Representation of Oscillator Performance $\sigma_y$**

from 14h20 to 15h10 - David A. Howe - NIST - Boulder, CO, USA

Variances (ADEV, MADEV, TDEV, HDEV, TOTDEV, ...) and variance measurements

## **1.5 Quartz Oscillators**

Monday June 30 from 15h10 to 16h00 - Jean-Pierre Aubry - consultant (F)

Why do we need quartz oscillators - Basic quartz oscillators: TCXO, VCXO, OCXO, BVA, MCXO - Waves and materials: BAW, SAW - Quartz resonators - Non-Quartz devices - Oscillators and Frequency synthesis for Atomic Clocks - Comparison and future

## **1.6 Introduction to Atomic Clocks**

Tuesday July 1 from 9h to 9h50 - Gaetano Mileti - Uni Neuchâtel (CH)

Basic principles and building blocks - Categories and examples of atomic clocks.

## **1.7 Space Projects**

Tuesday July 1 from 9h50 to 10h40 - Noël Dimarcq - CNRS-LNE-Syrté (F)

## **1.8 Synchronisation over Networks**

Tuesday July 1 from 11h10 to 12h00 - Jean-Pierre Aubry - consultant (F)

Various networks T&F requirements - Basics on Frequency & Time - Telecom: fix line infrastructure and wireless - Power Networks / Smart Grid requirements - GNSS vulnerabilities - Solutions for time transfer over networks - Secure Power Network Timing - Path toward future technologies

## **1.9 White Rabbit Techniques**

Tuesday July 1 from 12h00 to 12h50 - Javier Serrano - CERN (CH)

Development of distributed real-time controls and data acquisition systems with precise synchronisation - Technologies used in White Rabbit (WR), performance measurements, currently available open WR-compliant products with commercial support - Current and foreseen applications of WR

## **1.10 Atomic Clock Physics**

Tuesday July 1 from 16h30 to 17h20 - Gaetano Mileti - Uni Neuchâtel (CH)

Magnetic resonance and generalised Bloch equations - Tunable lasers and basics of atom-light interaction - Main fields of applications and specific examples

## **1.11 Relativity for Reference Systems and Time Metrology**

Wednesday July 2 from 9h to 9h50 - Gérard Petit - BIPM

Introduction to the theory of relativity - Current definitions and realisations of space-time reference systems for the Solar system and for the Earth - Applications in the geocentric system

## **1.12 Time Scales**

Wednesday July 2 from 9h50 to 10h40 - Gérard Petit - BIPM

Definitions and interrelations of TT, TT(BIPM), TAI, UTC, UTC(k), UTCr - Main features of TAI / UTC - Primary and secondary frequency standards - UTCr, a rapid realisation of UTC

## **1.13 Time Transfer I - Global Navigation Satellite System (GNSS)**

Wednesday July 2 from 11h10 to 12h00 - Andreas Bauch - PTB Braunschweig (D)

Clock requirements - Reference Time Scale - GNSS signal structure and modelling - Ionosphere and observation equations - Satellite position and clock - Satellite clock correction - Troposphere delays - GPS codes and phases - Satellite synchronisation systems - GNSS Time Transfer

## **1.14 Very Long Base Interferometry (VLBI)**

Wednesday July 2 from 12h00 to 12h50 - Ulrich Schreiber - TÜ München (D)

The use of Time & Frequency in space geodesy - Global terrestrial reference frame with 1 cm accuracy - Requirements for the monitoring of global change on Earth - Demanding future applications

## **1.15 Time Transfer II - Two-way Satellite Time & Frequency Transfer (TW-STFT)**

Wednesday July 2 from 14h20 to 15h10 - Andreas Bauch - PTB Braunschweig (D)

Use of TWSTFT between ground and the International Space Station - The ACES project and space-born time dissemination devices - Time dissemination using long wave signals

## **1.16 Optical fibre link for ultra-stable frequency dissemination**

Wednesday July 2 from 15h10 to 16h00 - Anne Amy Klein - LPL Villetaneuse (F)

Ultrastable optical fibre links - Current developments and applications

## **1.17 Ultra Stable Lasers**

Thursday July 3 from 9h00 to 9h50 - Clément Lacroûte - FEMTO-ST (F)

Fabry-Perot interferometer basics - Ultra-stable Fabry-Perot cavities - FP cavities geometries: a review - FP cavities: state of the art

## **1.18 Small Clocks**

Thursday July 3 from 9h50 to 10h40 - Christophe Affolderbach - Uni Neuchâtel (CH)

## **1.19 Cold Atoms**

Thursday July 3 from 14h20 to 15h10 - Clément Lacroûte - FEMTO-ST (F)

Optical forces on neutral atoms - Magneto-Optical traps - Cold Atom Clocks: a few examples

## 1.20 Femtosecond Optical Combs

Thursday July 3 from 15h10 to 16h00 - Anne Amy Klein - LPL Villetaneuse (F)

Introduction, how to measure an optical frequency - The femtosecond laser as a frequency ruler  
- Frequency metrology with an optical frequency comb

## 1.21 Optical Clocks

Friday July 4 from 9h45 to 10h35 - Jérôme Lodewyck - (F)

Basic principles of optical clocks - Motional effects and trapping techniques - Comparison of two families of optical clocks: ion and optical lattice - Perspectives

## 1.22 Leeson Effect

Friday July 4 from 10h35 to 11h25 - Enrico Rubiola - FEMTO-ST (F)

The Leeson effect in a nutshell - Phase noise and friends - Heuristic explanation of the Leeson effect - Phase noise in amplifiers - Oscillator hacking - Resonator theory - Formal proof for the Leeson effect - The Leeson effect in delay-line oscillators - AM-PM noise coupling

## 1.23 Servo Loops

Friday July 4 from 11h25 to 12h30 - Gonzalo Cabodevilla - FEMTO-ST (F)

## 2 Hands-on lab sessions

Total number of hours, hands-on lab sessions: 10 hours.

- Lab 1 Oscillator Measurements  $S_\phi / \sigma_y$
- Lab 2 Surface Acoustic Wave piezo devices and related wireless sensors
- Lab 3 GPS receivers, pseudo-random codes, practical implementation
- Lab 4 Microwave Photonics - Optical Fibre Time & Frequency systems
- Lab 5 Transportable and miniature Cold Atoms Atomic Clocks
- Lab 6 Computer simulation and processing of T&F measurements

Lab sessions schedule

Lab	day	time	contents
Lab 1	Monday June 30	16h30 to 18h10	Oscillators $S_\phi / \sigma_y$
Lab 2 (// 3) * note 1	Tuesday July 1	14h20 to 16h	Surface Acoustic Wave piezo devices
Lab 3 (// 2)	Wednesday July 2	16h30 to 18h10	GPS, pseudo-random codes
Lab 4 (// 5) ** note 2	Thursday July 3	11h10 to 12h50	Microwave Photonics - Optical Fibres
Lab 5 (// 4)	Thursday July 3	16h30 to 18h10	Transportable and miniature Atomic Clocks
Lab 6	Friday July 4	14h20 to 16h	Computer simulation and processing

\* note 1: on Tuesday afternoon, one group will follow Lab 2 (SAW) and the other group will follow Lab 3 (GPS). Groups will exchange Labs 2 / 3 on Wednesday afternoon.

\*\* note 2: on Thursday morning one group will follow Lab 4 (Microwave Photonics) and the other group will follow Lab 5 (Miniature Atomic Clocks). Groups will exchange Labs 4 / 5 in the afternoon.

### 3 Visits & social programme

Monday	June 30	Visit of the Besançon Observatory
Tuesday	July 1	Visit of the Besançon Museum of Time (horological collections)
Wednesday	July 2	Night sessions with the observatory's telescopes (according to weather conditions)
Thursday	July 3	Banquet
Friday	July 4	Lab tour, FEMTO-ST institute

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#### Contacts :

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