

# **Curriculum Vitae of Prof. Gaetano Mileti**

## **1) Personal information**

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### Scientific communications:

In peer-reviewed journals **62** articles  
In books and special publications **5** articles in books + **21** ESA and SPIE special issues  
Other communications **98** articles in conference proceedings and special reviews  
**106** other conference presentations (oral or posters)

Complete list available at: <http://www.unine.ch/gaetano.mileti> and <http://www.unine.ch/ltf>

## **2) Studies and education**

1986 - 1991 *École Polytechnique Fédérale de Lausanne (EPFL), ingénieur physicien  
Diploma subject (mathematical physics): non adiabatic transitions*  
1991 - 1995 *PhD work at Observatoire Cantonal de Neuchâtel (UNINE): Rb atomic clocks  
and frequency-stabilized lasers. Title: «Étude du pompage optique par laser  
et par lampe spectrale dans les horloges à vapeur de Rubidium»*

## **Internships and post-doc**

Summer 1989 *Paul Scherrer Institute (PSI), Villigen (AG), Switzerland: simulation studies  
on molecular dynamics*  
1991 *EPFL (Institut de Physique Théorique): Berry phase and non-adiabatic  
transitions in two-level quantum systems*  
1995-1997 *Post-doc guest researcher at the «National Institute of Standards and  
Technology» (NIST) in the «Time and Frequency» Division, Boulder (CO),  
USA, funded by the SNSF and NIST. Subject: «Double resonance signal and  
super local oscillator with a laser pumped Rb vapor»*

## **3) Employment history**

1991-1995 *Scientific collaborator at the Observatoire Cantonal, Neuchâtel, Switzerland  
1991-1993: research on lamp-pumped industrial and space Rubidium clocks  
1993-1995: research on laser-pumped Rubidium clocks*  
1995-1997 *Post-doc at NIST (Boulder, USA) on laser-pumped gas-cell atomic clocks*  
1997-2001 *Senior scientific collaborator at the Observatoire Cantonal  
1997-1999: research on stabilised lasers for airborne and spaceborne Lidars  
1999-2001: research on laser cooling of neutral atoms and primary Caesium  
frequency standards (Swiss continuous atomic fountain for METAS)*  
2001-2006 *Group leader at the Observatoire Cantonal (Rb clocks and stabilised lasers)*  
Since 2007 *Cofounder and deputy director of the «Laboratoire Temps – Fréquence»  
(LTF) in the Institute of Physics of the University of Neuchâtel, Switzerland  
Head of the group working on frequency standards and stabilised lasers*

## **4) Institutional responsibilities (Canton and University of Neuchâtel)**

Official nominations *Group leader since 2001 (in Observatoire Cantonal de Neuchâtel)  
2005 «Collaborateur scientifique sénior», «Chef de projet», Observatoire NE  
2007 «Directeur adjoint du Laboratoire Temps - Fréquence», University NE  
Ad interim director of the Institute of Physics (01.08.2011–31.12 2011)*  
Academic titles *Since 01.04.09: «Directeur de recherche» at the University of Neuchâtel  
Since 01.02.2012: «Professeur associé» at the University of Neuchâtel*

## 5) Research projects

Prof. Mileti was appointed as group leader in 2001. Since then, he has been involved in approximately 50 externally-funded research projects (total funding of ~ 50 Million Swiss Francs), as coordinator, principal investigator or co-investigator. These projects were funded by the Swiss National Science Foundation (SNF), Innosuisse (formerly CTI/KTI), the Swiss Space Office, the European Union (under various programs), the European Space Agency (ESA) and several other public or private entities.

These projects were conducted in collaboration with several (nearly 100) Swiss and foreign specialized Universities, laboratories and private companies. More generally, his research, teaching and scientific communications activities involve frequent contacts with most Time & Frequency institutes over the world, especially those specialized on vapour-cell atomic spectroscopy, atomic clocks and stable lasers.

## 6) Supervision of junior researchers at graduate and postgraduate level

Presently director of **2 PhD students**: Nil Almat and Etienne Batori

Director or co-director of 7 completed PhD theses at the University of Neuchâtel (2011-2018): Laurent Devenoges, Thejesh Bandi, Matthieu Pellaton, Danijela Miletic, Sylvain Karlen, Mohammadreza Gharavipour and William Moreno. Member of the jury of more than 10 PhD and habilitation theses at: EPFL (CH), the University of Franche-Comté (F), the University of Siena (I), the University of Pierre and Marie Curie (F) and the University of Montpellier (F).

## 7) Teaching activities

Lecture: "**Energie mécanique et thermodynamique**" at the University of Neuchâtel since 2013

Lecture: «**Compléments de Physique générale I-II**» at the University of Neuchâtel since 2009

Responsible of the «**Laboratoires de Physique I-II**» at the University of Neuchâtel (2007 - 2010)

Lectures: «**Spectroscopie et refroidissement d'atomes par laser**», University of Fribourg (2005)

Lectures: «**Électronique Quantique**» with Prof. G. Busca, and «**Chapitres choisis de physique atomique: interaction atomes – rayonnement**» with Prof. P. Thomann, (1991-2005)

Responsible of master, diploma and other undergraduate internships at the Observatoire Cantonal and the University of Neuchâtel (since 1998)

Series of lectures: «**Atomic clocks: basic principles and applications**» at CUSO (2010, 2012, 2014)

Lectures at the «**European Frequency and Time Seminar**» every year since 2013 in Besançon (F)

Tutorial: «**Compact Atomic Clocks**» at the joint IEEE IFCS – EFTF 2013, Prague, 2013

Lecture: «**Space atomic clocks and their miniaturisation**», «Highlights in Microtechnology», (2016)

Lectures: «**Time and Frequency** », at the «Swiss Innovation Academy», CSEM, 2007

Lecture: «**Physics of atomic clocks** », «Engelberg lectures on optics: Photonics in space», (2007)

## 8) Memberships in panels, boards and individual scientific activities

Chairman of the Scientific Committee of the EFTF (European Frequency and Time Forum) for 2013-2015 and member of the Executive Committee of the EFTF since 2012

Member of Technical Program Committee of the IEEE International FCS (Frequency Control Symposium)

Member of the Scientific Council and co-founder of the EFTS (European Frequency and Time Seminar)

Member of the Jury of the "Concours International d'Horlogerie", Le Locle

Member of the Jury of the "Institut Neuchâtelois"

## 9) Active memberships in scientific societies, fellowships in renowned academies

Swiss Physical Society (SPS)

Optical Society of America (OSA)

Institute of Electrical and Electronics Engineers (IEEE)

Association Suisse pour la Recherche Horlogère (ASRH)

## 10) Organisation of scientific conferences

2013 Co-chair of the 2013 Joint IEEE UFFC, EFTF and PFM Symposium held in Prague in July 2013

2014 Member of the Local Organising Committee of EFTF-2014, Neuchâtel, June 23-26 2014

2015 Co-chair of the 2015 Joint IEEE IFCS and EFTF conference, Denver, April 12-15 2015

2019 Co-general chair of the joint EFTF-IFCS 2019 (April 14-18, Orlando), <http://ifcs-eftf2019.org/>

## **Major scientific achievements in science and scientific outreach of Prof. Gaetano Mileti**

### **a) Scientific achievements**

I am working in the domain of laser spectroscopy and atomic clocks since 1991. After having participated to the development of "traditional" lamp-pumped Rubidium vapour frequency standards for ground and for space applications (1991-1995, Observatoire Cantonal de Neuchâtel) my research focused on the study of resonant atom-laser interaction and the exploitation of laser diodes for a new generation of high precision and/or miniature instruments. During a post-doc at NIST (Boulder, Colorado, USA), from 1995 to 1997, we achieved - for the first time - a short-term frequency stability of the order of  $10^{-13}$  after a few seconds of averaging time.

Back in Neuchâtel, I pursued this research. I formed my own group in 2001 and have been leading it since then. We have gradually improved the medium to long-term frequency stability through an accurate evaluation and suppression of each systematic effect. In parallel, we have launched, in 2004, one of the first European project aiming to develop a chip scale atomic clock.

During these years, I also gave significant contributions to the research on laser cooling held in Observatoire Cantonal de Neuchâtel and took part to the development of the Swiss Primary Frequency Standard, the continuous Cesium fountain, now operated in METAS, the Swiss National Metrological Institute.

In 2006, I have co-founded the Laboratoire Temps - Fréquence (LTF) in the University of Neuchâtel. This transfer has allowed to enhance my field of basic research and to enrich my involvement in educational and outreach activities. Some of them are described below.

I presented the main recent scientific achievements of my group in the following talks:

C. Affolderbach, N. Almat, M. Gharavipour, F. Gruet, W. Moreno, M. Pellaton, G. Mileti, *Selected studies on high performance laser-pumped Rubidium atomic clocks*, **Talk** at the International Frequency Control Symposium (IFCS), Olympic Valley, California, USA, May 22-24, 2018

C. Affolderbach, T. Bandi, M. Gharavipour, F. Gruet, S. Kang, R. Matthey, M. Pellaton, G. Mileti, *High performance and miniature vapor cell frequency standards*, **Invited plenary talk** at the 8<sup>th</sup> Frequency Standard and Metrology Symposium, Potsdam, Germany, October 12-16, 2015

T. Bandi, M. Pellaton, D. Miletic, C. Affolderbach, F. Gruet, R. Matthey, G. Mileti, C. Stefanucci, M. Violetti, F. Merli, J.-F. Zürcher, A. K. Skrivervik, *Double Resonance in Alkali Vapor Cells for High Performance and Miniature Atomic Clocks*, **Invited talk** at the IEEE International Frequency Control Symposium, Baltimore, USA, 2012

### **b) Education and scientific outreach** (see [www.unine.ch/gaetano.mileti](http://www.unine.ch/gaetano.mileti) for more details)

Since 2006, in the University of Neuchâtel, education and organisation of scientific events have become a much more important part of my professional activity. For instance, I have served as Scientific Chair, General chair and Tutorial chair in the most important European Time & Frequency conference (EFTF).

After the creation of LTF, I have also been strongly involved in the organisation of local events (MICRO-12-14-18: <http://micro16.ch/>), and the founding of a specialised European school (EFTS: European Frequency and Time Seminar: [www.efts.eu](http://www.efts.eu)).

During all these years, I had many opportunities to present my research and the underlying science (in particular in the field of metrology and of atomic physics) to a broader public, also in the national and international Medias (<http://www.unine.ch/gaetano.mileti/home/interventions-dans-les-medias.html>).

More recently, I gave the following talks in which I highlighted the fact that the history of measurement of time is closely related to the history of natural science and to several technological breakthroughs:

- "*Recherches neuchâteloises sur les horloges atomique*", Formation et excellence, 60<sup>ème</sup> anniversaire du Musée de l'horlogerie du Locle, Salle 407, Ancienne Poste, 20 juin 2019 : [http://www.unine.ch/files/live/sites/ltf/files/shared/documents/Evénements/20%20juin%202019%20manifestation%20Ancienne%20Poste\\_%20flyer.pdf](http://www.unine.ch/files/live/sites/ltf/files/shared/documents/Evénements/20%20juin%202019%20manifestation%20Ancienne%20Poste_%20flyer.pdf)
- "*Towards a new definition of the second?*", at the SIHH 2019 – Salon International de la Haute Horlogerie, Genève, 16 janvier 2019 ([www.youtube.com/watch?v=a3oEHU8-hg](http://www.youtube.com/watch?v=a3oEHU8-hg))
- «*Recherches sur les horloges atomiques*», 7<sup>ème</sup> Biennale du patrimoine horloge, Club 44, La Chaux-de-Fonds, 5 novembre 2016
- «*Horlogerie: au poignet et dans l'espace!*», Café scientifique UniNe, 23 mars 2016, *recording*: [https://www.unine.ch/files/live/sites/cafescientifique/files/shared/son/23mar2016\\_cafeIn\\_avenir\\_horlogerie.mp3](https://www.unine.ch/files/live/sites/cafescientifique/files/shared/son/23mar2016_cafeIn_avenir_horlogerie.mp3)

**c) Research projects** (see <http://www.unine.ch/gaetano.mileti/home/projets-de-recherche.html>)

Since the creation of my own research group, in 2001, I have been principal investigator or co-investigator of **more than 50 externally-funded research projects**, corresponding to a total external funding (part under my direct guidance) of **approximately 15 million Swiss Francs**. Most of these projects concern precision atomic laser and microwave spectroscopy, laser cooling, stabilised laser diodes and atomic frequency standards.

Among the on-going or recently completed research projects, in addition to the FNS 200020-156621 subsidy, the team has conducted several national and international scientific collaborations funded by the FNS-SCOPES program, the European Space Agency through the Swiss Space Center and Innosuisse. The group is also part of consortium that started on October 1<sup>st</sup> 2018 a project selected in the frame of the FET-Open "Quantum Technologies" EU program ("Flagship on Quantum Technologies").

Last year, several other projects were concluded, in particular one aiming to develop the [first 3D-printed microwave cavities for atomic clocks](#), funded by the Swiss Space Office, under the "Mesures de Positionnement" (Space Technologies Studies 2014: <https://www.spacecenter.ch/activities/events/mdp2016results/>).

Among the projects successfully completed before 2018, the following ones deserve a mention:

- SNF Sinergia project no. [122693](#) "Miniature atomic clocks and quantum sensors"
- EU-FP7 project [MAC-TFC](#), grant no. 224132
- EMRP project IND-55 [MCLOCKS](#), "Microwave clocks for industrial applications"
- Doctoral Fellowship of the European Space Agency ESA, (PhD thesis of M. Pellaton)

The group's research expertise has also enabled participation in several application-oriented projects with national and international industry partners (Swiss Commission for Technology and Innovation, CTI, now renamed Innosuisse) such as:

- [Quantime](#): a Cs miniature atomic clock, CTI project n. 13818.2
- Low-cost Interferometer, CTI Project n. 12344.1 PFNM-NM
- [Cesium Optique Sol](#), CTI Project n. 14750.1 PFNM, [EURIPIDES project](#)
- Primary Compact Cesium Clock – PC3, CTI project n. 25.367

**d) Examples of recently achieved results**

Among the recent scientific achievements, one could point out in particular:

- The experimental and theoretical evidence of the so-called "**barometric effect**", limiting the performances of Rb clocks, due to the natural variations of ambient atmospheric pressure (2017-2018);
- The demonstration of a clock operation using **frequency-doubled telecom laser** in a Rubidium vapour-cell standards (2017-2018);
- The development and use of a **3D-printed microwave cavity** in an atomic clock (2017);
- The measurement, imaging and NMR-inspired studies of **hyperfine relaxation times** in alkali vapour cells (2015-2017);
- The realisation of **compact wavelength references around 1.6 μm** for atomic clocks and CO<sub>2</sub> detection (2015).
- The **aging studies of micro-fabricated alkali vapour-cells** (2015);
- **Optical pumping** and double resonance in a micro-fabricated cell **using a micro-fabricated discharge lamp** as optical source (2014)

In addition to basic results that are relevant for a better understanding of the resonant interaction between an electromagnetic field (microwave and optical) with an ensemble of atoms, the research of the group has also contributed to the emergence of a new generation of laser-based frequency standards and wavelength references.

The group can therefore claim a well-established and recognised leadership in its specific domain.