

PhD position in ultrafast/nonlinear optics & astrophotonics:

“A 16-GHz electro-optic astrocomb for the H+K bands”

Scientific Context

The detection and characterization of exoplanets is one of the most dynamic and impactful research fields in modern astrophysics [1]. High-resolution spectroscopy (HRS) is a cornerstone of this effort, enabling the detection of the subtle stellar wobbles induced by orbiting exoplanets [2] and the analysis of their atmospheric chemical composition. However, HRS demands calibration sources of exceptional precision, offering broadband coverage, long-term stability, and robustness against environmental fluctuations. Astrocombs—octave-spanning optical frequency combs tailored for astronomical applications [3]—offer a promising route to unprecedented wavelength-calibration accuracy by linking astronomical spectrographs to precision time-frequency standards. Yet, current implementations face critical limitations, including large line spacing, narrow operational bandwidth, and excessive system complexity and fragility hindering their widespread adoption in observatories.

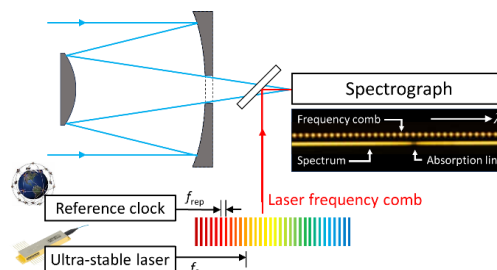


Figure 1. Calibration of a high-resolution spectrometer with a referenced frequency comb.

Research / Job description

This PhD project aims to explore a new approach to astrocomb design, building on techniques and ideas developed within TRACES¹, an ANR-funded research consortium gathering the Institut de Physique de Nice (INPHYNI²), the Institut de Planétologie et d'Astrophysique de Grenoble (IPAG³) and the Laboratoire Photonique, Numérique et Nanosciences (LP2N⁴). The goal is to engineer a next-generation astrocomb for the H+K bands (1.4–2.5 μm), combining innovative approaches: (1) electro-optic comb generation [4], (2) burst operation for enhanced efficiency, (3) Yb-doped fiber technology for power scaling, (4) polarization-maintaining all-normal-dispersion photonic crystal fibers [5] for robust spectral broadening, and (5) intrapulse difference-frequency generation (iDFG) to achieve a flat, and phase-stable ultra-broadband spectrum.

The candidate will focus on theoretical modeling and numerical simulations of spectral broadening in photonic crystal fibers and of the iDFG stages, the experimental development and validation of these stages to produce a highly stable, tunable, and field-deployable astrocomb, and collaborative on-sky testing with IPAG to validate the system's performance in real-world conditions.

This interdisciplinary and exploratory project offers a unique opportunity to work at the intersection of laser physics, nonlinear optics, and astrophysical instrumentation and to join a multidisciplinary team of experts in optics, lasers, and instrumentation.

The student will receive a full scholarship (monthly gross salary of ~2 135 €, 36 months) and will be enrolled in the PhD program “Fundamental and Applied Sciences” of the Université Côte d’Azur (ED.SFA). The funding of the PhD is secured by an ANR grant and with a start in November or December 2026 (flexible).

Supervisor and contact

Nicolas Forget, INPHYNI (Université Côte d’Azur, CNRS): nicolas.forget@univ-cotedazur.fr

¹ <https://anr.fr/Projet-ANR-25-CE31-3944>

² <https://inphyni.univ-cotedazur.fr>

³ <https://ipag.osug.fr>

⁴ <https://www.lp2n.institutoptique.fr>

Methods, expected results and planning

Context/Astrocombs - High-resolution spectroscopy (HRS) for exoplanet detection and characterization demands calibration sources of unprecedented precision, stability, and broadband coverage. Another interesting application of astrocombs might be the detection of cosmic acceleration if the stability and resolution of astrocombs could be extended over very long observation periods. Current astrocombs, while effective, often suffer from limited bandwidth or excessive complexity, which restrict their usability in astronomical observatories. To address these challenges, this PhD project will develop a 16-GHz next-generation astrocomb tailored for the H+K bands (1.4–2.5 μm), leveraging a novel combination of ultrafast optics and nonlinear frequency conversion techniques.

Originality of the research – This research stands at the intersection of ultrafast optics and astrophysical instrumentation, where shared challenges—such as wide spectral coverage, phase stability, and environmental robustness—drive cross-disciplinary innovation. The proposed approach integrates, for the first time:

- The generation of a first 16-GHz comb at 1030 nm by electro-optic modulation and post-compression
- Burst-mode amplification in Yb-doped fiber amplifier to enhance efficiency and flexibility,
- Spectral broadening in polarization-maintaining all-normal-dispersion photonic crystal fibers,
- Intrapulse difference-frequency generation to achieve a flat, ultra-broadband spectrum in the H+K bandwidth

This synergy enables the generation of highly accurate, stable, and spaced spectral lines, meeting the stringent requirements of modern HRS instruments for exoplanet.

Expected results – The PhD candidate will contribute to the following key outcomes:

- Theoretical and numerical validation of the spectral broadening in PM-ANDi fibers and of the difference-frequency generation, including optimization of parameters (e.g., fiber length, phase matching, dispersion management) for maximum efficiency, bandwidth and stability;
- Experimental demonstration of a prototype astrocomb, tied to a time-frequency standard such as REFIMEVE⁵, with uniform line spacing (16 GHz) across the H+K bands (1.4–2.5 μm), flat spectral density, long-term stability and environmental robustness (tolerance to temperature and mechanical perturbations);
- On-sky validation in collaboration with IPAG: the astrocomb will be tested on a high-resolution spectrograph installed on a meter-class telescope to assess its performance in real-world conditions;
- Publication of results in high-impact journals and presentations at international conferences.

Tasks and responsibilities

- Demonstrate a high level of commitment and personal initiative to undertake the necessary efforts to ensure good progress in the research project, which includes the development of the research methodology, the analysis and communication of the research results;
- Be aware of, and adhere to, the generally accepted norms of responsible conduct of research: document your work, promoting open science through research data management, respect the intellectual property rights relating to concepts and findings of UCA or any other relevant institution, proper care of materials and equipment etc;
- Follow the training sessions (90 hour-standard course) of the ED.SFA, attend the induction /welcome meeting and the symposium of the ED.SFA;
- Together with your supervisor, build a plan for your PhD program: research-related training and activities, as well as soft skills. These will help advance the quality and efficiency of your research and prepare you for a professional career. You ensure that the activities in the context of the doctoral program are completed within the proposed deadlines;
- Supervise Bachelor/Master theses and tutoring students.

What do you have to offer?

You hold an MSc. (or equivalent) in physics, have done an experimental master project (or equivalent) in an optical, atomic, molecular or quantum physics lab. Other skills and documents that would benefit your application are:

⁵ <https://www.refimeve.fr>

- hands-on experience with experimental techniques used in ultrafast optics optics, such as lasers, fibers, optics;
- working knowledge of a programming language (Python, Matlab or equivalent);
- good English oral and written communication skills;
- good French oral and written communication skills are not mandatory but are appreciated.

To foster diversity in our research group, we will especially appreciate applications from groups underrepresented in science.

Our offer

We offer a temporary contract of **3 years**, starting at the **end of 2026**. You will be enrolled in the ED.SFA PhD program of the Université Côte d'Azur. The gross monthly salary is **~2 135 €**.

The student will work closely with a multidisciplinary team of scientists and instrumentation experts. and will have access to state-of-the-art laboratory facilities and collaborative partnerships with leading international astronomical institutions. Besides the salary and a vibrant and challenging environment, we offer you multiple fringe benefits: 5 weeks of holidays, a complete educational program for PhD students with multiple courses on topics and soft skills, help with accommodation, partial coverage of public transport costs etc.

About the Université Côte d'Azur and the Nice Institute of Physics

Université Côte d'Azur (UCA) now includes 17 major academic establishments around the historic university core to create one of France's top 10 research-intensive universities. UCA was awarded the prestigious 'Initiatives of Excellence' certification label, which highlights the quality of its research and ensures that it has a high visibility international profile. The university's research strategy aims to create synergies between the research teams to explore new interdisciplinary areas while maintaining its level of excellence in academic fields. It is part of a coherent and ambitious site policy jointly developed with other players in research, higher education and the socio-economic world.

The Nice Institute of Physics is a mixed research unit (UMR 7010) affiliated with the University Côte d'Azur (UCA) and the French National Center for Scientific Research (CNRS). INPHYNI's activities are structured around three, principal axes: waves and quantum physics, photonics and nonlinear physics, complex fluids, and biophysics. Projects developed around these topics cover theoretical, fundamental, and experimental aspects as well as applications. These projects benefit especially from the support of technological platforms and technical shared services. The Institute moved to a brand-new building in March 2023.

Contact and job application

If you feel the profile fits you, and you are interested in the job, we look forward to receiving your application. Please submit your application apply online via the button below and by email to:

nicolas.forget@univ-cotedazur.fr

Applications should include the following information:

- a detailed CV including the months when referring to your education and work experience;
- the name and email address of at least one reference who can provide a letter of recommendation.

The first interview will usually be held within a few weeks of the reception of an application from a suitable applicant.

Bibliography

1. O. Guyon, "Habitable exoplanets detection: overview of challenges and current state-of-the-art [Invited]," Opt. Express **25**, 28825 (2017).
2. T. Wilken, G. L. Curto, R. A. Probst, T. Steinmetz, A. Manescau, L. Pasquini, J. I. González Hernández, R. Rebolo, T. W. Hänsch, and T. Udem, "A spectrograph for exoplanet observations calibrated at the centimetre-per-second level," Nature **485**, 611–614 (2012).
3. A. (A. J.) Metcalf, "Astrocombs: Recent advances," IEEE Journals & Magazine (2020).
4. H. Ye, F. Leroi, L. Pontagnier, G. Santarelli, J. Boullet, and E. Cormier, "High-power nonlinear amplification of an ultrafast electro-optic frequency comb with flexible GHz repetition rate," Scientific Reports **12**, 1 (2022).
5. R. Morel, J. Millo, N. Forget, V. Thibaut, M. Marcadier, A. Jullien, Y. Pertot, A. Cassez, V. Andrieux, D. Labat, O. Vanvincq, A. Kudlinski, J. M. Dudley, and T. Sylvestre, "Novel photonic crystal fibre for low-noise coherent supercontinuum generation," Scientific Reports **16**, 14901 (2026).