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POST DOCTORAL POSITION

Title : RAMA: From first light to intelligent operations: next-generation adaptive optics on sky for astronomy, space surveillance and optical communications

Reference : **PDOC-DOTA-2026-AI4AO**

Contract start: 1 January 2027	**Application deadline: 1 December 2026**

Duration: 18 months; gross salary: approximately €38k per year (health insurance included)

Keywords:
Adaptive optics; on-sky experimentation; high-angular-resolution imaging; space surveillance; free-space optical communications; real-time control; system identification; telemetry; machine learning; autonomous operation

Adaptive optics has learned to correct the atmosphere; the next step is systems that understand themselves, adapt to their target and keep improving with every night of data. RAMA was built to take new sensing, control and AI-assisted concepts from simulation to repeated validation on the real sky: on stars, moving satellites and optical links. The fellow will be at the heart of this platform, as ***RAMA's system and exploitation scientist****: the person who runs it, characterises it, optimises it and turns it into results."*

Context

A rare on-sky environment for next-generation adaptive optics. RAMA is an experimental AO platform installed on FEELINGS, ONERA's 60-cm optical ground station at Le Fauga-Mauzac near Toulouse. FEELINGS can acquire and track low-Earth-orbit satellites and was originally developed for ground-to-space optical links. The same facility therefore gives direct access to stellar and planetary imaging, resolved satellite observations and optical-communications experiments together with a documented propagation environment. First light, obtained in August 2026 only four months after project kick-off, delivered diffraction-limited stellar images in the R band. The very first commissioning nights already identify the main loop limitations, in calibration, measurement noise and temporal behaviour, and the corresponding margins to improve, optimise and fully exploit the system.

An open platform built to evolve. RAMA is developed within AI4AO and built around DAO, the open Durham Adaptive Optics real-time architecture. Its telemetry streams and control interfaces allow new sensing, reconstruction and control strategies to be inserted directly in the loop, including GPU inference. RAMA can therefore host approaches beyond current operational practice: non-modulated pyramid sensing with neural reconstruction [Weinberger et al. 2024], CNN-based reconstruction [Oyarzun et al. 2026], data-driven predictive control such as PO4AO, atmospheric channel monitoring along the line of sight and cascaded two-stage correction with a high-bandwidth booster deformable mirror. Visible/SWIR imaging, satellite tracking, single-mode-fibre coupling, RAMA Twin and OOPAO complete the environment.

Postdoctoral project :

Make the whole system scientifically productive. Several PhD students and postdoctoral researchers already developed individual building blocks such as predictive and reinforcement-learning control, neural wavefront reconstruction, advanced sensing and multi-stage correction. The fellow's role is complementary and deliberately system-level, at the interface between physics, algorithms, AI, software and experimentation, and is organised around four missions.

(1) Extend the first-light error budget into a statistically grounded characterisation of the operating envelope, built from hundreds of observing sequences and a curated, versioned telemetry database.

(2) Bring selected AI4AO developments onto the telescope (double stage DM, new WFS and control algorithm, Event-based Camera for innovative imaging scheme coupled with AO, VIS vs SWIR comparison, …) and benchmark them on sky against well-tuned classical baselines, with identical data, latency and validation protocols, first in telemetry replay and on the digital twin, then in closed loop.

(3) Compare the three operating regimes and connect classical adaptive-optics metrics to operation and mission metrics: exploitable image content for space surveillance, coupled power and channel stability for optical links.

(4) Push the most mature functions towards automated calibration, acquisition, performance monitoring and controller tuning, and formalise the concepts of operation to be transferred to future systems.

"One scientific question to rule them all": *how should the same adaptive-optics system be characterised, tuned and controlled when the target and the final mission metric change?* Answering it requires a statistically representative link between telemetry, atmospheric conditions, calibration state, target properties and achieved performance, across astronomical point sources, extended and rapidly moving space objects, and optical links where coupled power and channel stability can matter more than image quality. The aim is not a single best-case number, but a quantitative map of the RAMA operating envelope and of the strategy best suited to each regime.

From measured data to the digital twin. The dialogue between experiment and simulation is the scientific engine of the project. Every observing night enriches the versioned telemetry base; these records anchor RAMA Twin, the OOPAO-based replica of the bench, to measured interaction matrices, temporal transfer functions, noise levels and turbulence conditions. The twin then becomes an instrument in its own right, a place where hypotheses about the system are formulated, confronted with sky data and revised. Artificial intelligence enters the loop on both sides. In simulation, the twin gives learning-based controllers and the AI4AO bricks a training ground with no sky-time cost, and the quality of their transfer to the real bench becomes an experimental result in itself. On the experimental side, learned models extract from telemetry what classical identification captures poorly, mis-registrations, optical gains and non-stationarities, and feed them back into the twin. Each recorded night thus multiplies into simulated nights, each simulation returns to the sky as a falsifiable prediction, and the pair converges towards a system that is understood as well as it is corrected.

A publication programme of its own. The fellow will be first author on the on-sky characterisation of RAMA, the multi-regime question and the twin-to-bench transfer, and owns the benchmark framework in which other teams' bricks are evaluated: two journal articles and two to three conference papers are a realistic 18-month target.

A direct path to future instruments. Validated concepts and operating procedures will feed PROVIDENCE, ONERA's future 2.5-m high-angular-resolution telescope at Observatoire de Haute-Provence, future ground stations for quantum and deep-space optical communications, and the team's astronomical instrumentation activities including HARMONI on the ELT.

Candidate profile and training.
Applicants should hold a PhD in adaptive optics, optical instrumentation, control, optical communications, signal/image processing or machine learning applied to physical systems. Strong Python skills and a genuine interest in experimental work are expected. The fellow will gain hands-on experience in on-sky AO commissioning, open real-time/GPU control, telemetry-based system identification, digital twins, LEO satellite tracking, optical-communications experiments and validation of AI-assisted methods. The position suits someone who enjoys moving between models, code and the telescope.

Location.
Two arrangements are possible. The fellow may be based at ONERA Le Fauga-Mauzac, near Toulouse, with regular stays at LAM in Marseille; alternatively, the position can be hosted at LAM, under the ONERA Salon-de-Provence centre, with regular missions to Le Fauga for hands-on work on the experiment. This flexibility rests on a concrete capability: both the FEELINGS telescope and the RAMA adaptive-optics bench can be operated fully remotely, so system tuning, observing runs and data exploitation do not depend on permanent physical presence at the telescope site.

References
https://onera.fr/fr/feelings · https://sites.google.com/view/ai4ao/ · https://onera.fr/fr/providence
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External collaborations

Laboratoire d'Astrophysique de Marseille (LAM), Bertin-ALPAO, Durham University, Universidad Católica de Valparaíso

Host laboratory at ONERA

Département : Département d'Optique et Techniques Associées (DOTA)

Location (ONERA centre): Salon-de-Provence / LAM (13) ou Le Fauga-Mauzac (31)

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