

# Scientific and Financial Reports for Visitor Dr Padelis Papadopoulos

During Dr Papadopoulos' visit in Leiden Observatory (18 May-1 July 2025), with myself as my main host, and Prof. Paul van der Werf as his co-host the following activities took place

## Talks:

- 1) Colloquium at Space Research Organization Netherlands (SRON)  
& Kapteyn Astronomical Institute, University of Groningen  
Wednesday 18th June 2025:

Title: "The possible thermal and dynamical states of the molecular clouds"

Abstract: A presentation of new results regarding the dynamical and thermal states of H<sub>2</sub> clouds in metal-poor and/or Cosmic-Ray intensive environments in the Galaxy and beyond. Their impact on the initial conditions of Star formation in galaxies across cosmic time will then be discussed.

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- 2) Colloquium in Leiden Observatory, Thursday 19th June 2025:

Title : "The neutral gas phase closest to Supermassive Black Holes, and possible new tests of General Relativity".

Abstract: The outline of recent work that indicates that neutral atoms and even molecules may survive in a neutral and potentially massive gas phase to within  $\sim(100-10^3)$  Schwarzschild radii around Supermassive Black Holes (SMBHs) in Active Galactic Nuclei (AGN). Besides its impact on AGN research, this could allow a fundamentally new type of General Relativity tests in strongly curved Spacetimes.

- 3) Talk in the Dusty Galaxies group meeting (Leiden Observatory)  
Wednesday 25th June 2025

Title: The initial conditions of Star formation in galaxies

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## Science activities while in Leiden Observatory (written by the visitor)

During my stay at Leiden Observatory and after quite a few meetings with Professor Viti, Paul van der Werf and Dr Violette Impelizzari we have converged to a very ambitious project to detect large amounts of neutral atomic and even molecular gas quite near the Supermassive Black Holes (SMBHs) found in galactic centers. The project is an outcome of and original idea neutral atoms and even molecules existing in dustless cold gas disks close to SMBHs. This is an idea proposed first by Thi & Papadopoulos 2004 (Astronomy & Astrophysics, 688, L20) which, if true, can have serious implications for a new class of tests in General Relativity regarding the Spacetime curvature near such SMBHs (Kostaros, Papadopoulos, & Pappas: Physical Review Letters 2024, 110.024001). During my stay in Leiden it was realized that thermal spectral line emission from molecules like CO, predicted to be abundant in such cold gas disks will be incapable of tracing the cold gas mass near SMBHs. However water (H<sub>2</sub>O) maser emission can be a far better bet in revealing such a gas disk around SMBHs along with H<sub>2</sub> rovibrational line emission. We (myself, Drs Viti, Impelizzari, Galimore and Thi) have now converged on a very bold plan, which will also involve researchers at the Observatoire de Paris (PSL) (Francoise Combes) to use the Atacama Large Millimeter Array in the Atacama Desert to discover H<sub>2</sub>O maser line emission in the Active Galactic Nucleus (AGN) of the galaxy NGC 1068. An application to ESO's GRAVITY near-IR interferometer in Paranal will also be made in order to detect H<sub>2</sub> rovibrational lines in such cold gas disks near SMBHs, in an effort that will involve also Professor Paul van der Werf in Leiden Observatory. Finally we agreed that Professor Viti will run dedicated astrochemical gas models to investigate just how close H<sub>2</sub>O molecules can exist near SMBHs in galactic centers, a truly exciting prospect!

## Financial Report

Dr Papadopoulos' expenses comprised his flight (Euros 683,37) and rent (he sublet a room from an ex colleague in Leiden) which was partially paid from Prof Viti's ERC budget and subsistence (food, national travel). For the latter, he has spent a total of 1069.93 for which receipts are attached and this is what he is claiming expenses for from NOVA.