

## **Three Decades of Dark Matter Annual Modulation Searches with NaI Detectors: Overview and Current Status of COSINUS**

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The search for an annual modulation in the event rate induced by the Earth's motion through the Galactic dark matter halo provides a powerful tool for discriminating potential dark matter signals from detector backgrounds. The DAMA/LIBRA experiment, a pioneer in exploiting this signature, has observed a modulated signal with very high statistical significance, exhibiting a period and phase consistent with dark matter expectations. However, these results remain in strong tension with the null results of most other direct detection experiments, and a fully model-independent experimental verification has still not been achieved.

COSINUS aims to address this long-standing puzzle by operating sodium iodide crystals as cryogenic scintillating calorimeters. Compared to other NaI-based searches, COSINUS offers several distinctive features: a low nuclear-recoil energy threshold, superior energy resolution, and event-by-event particle identification.

In this seminar, I will review the current global program of NaI-based dark matter searches and focus on the status of the COSINUS experiment. I will present recent results from the COSINUS prototype detector, describe the development of the dedicated low-background cryogenic facility at the Gran Sasso National Laboratory, and outline the ongoing commissioning toward the first physics data-taking campaign planned to start mid 2026. To conclude, I will discuss the remaining experimental challenges and the open questions that continue to keep this enduring puzzle unresolved.