

**ERC Synergy Grant 2025**  
**Research proposal [Part B1]**

Probe of the first microseconds of the Universe with  
cosmological magnetic fields

COSMOMAG

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**Host Institution:** Stockholm University (Nordita)
- **Proposal duration:** 72 months

Big Bang Nucleosynthesis, Cosmic Microwave Background and Large Scale Structure constitute the three solid observational grounds of modern Cosmology. However, we currently lack a probe of the state of the primordial plasma during the first microseconds of the Universe's history. Surmounting this frontier in our knowledge of the Universe is particularly compelling, since during this period, crucial beyond-Standard-Model phenomena should have happened: the thermalisation of the Universe, the spontaneous breaking of fundamental symmetries, the generation of the matter-antimatter asymmetry, the production of dark matter. The goal of COSMOMAG is to establish, for the first time, a probe of the first microseconds of the Universe, using cosmological magnetic fields. We will achieve this by combining information from multiple observational channels, which will allow us to trace the imprint of magnetic fields at different cosmological epochs. We will ascertain the presence of magnetic fields in the Large-Scale Structure of the present-day Universe, using the techniques of multi-messenger (gamma-ray, radio and ultra-high-energy cosmic ray) astronomy, leveraging the sensitivities of major observatories in each messenger channel. In parallel, we will constrain the presence of the magnetic field at earlier epochs, through its effect on the Cosmic Microwave and Stochastic Gravitational Wave Backgrounds. We will combine all available multi-messenger information from different electromagnetic and gravitational wave channels with the results of innovative numerical simulations, tracing the evolution of cosmic magnetism in time, from the moment of its generation in the early Universe, until today. This will allow us to build a comprehensive observational and theoretical approach linking the present-day magnetic field to the physics responsible for its generation in the first instants of the Universe.