Neutron stars as axion laboratories

Harnessing the power of the magnetosphere

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6

Epilogue

The mystery with which we started this thesis, that of the nature of dark matter, has a long-standing history and will likely continue to challenge scientists well into the future. From early observations of unexplained gravitational effects to the current sophisticated theoretical models and experimental searches, significant progress has been made thus far in our quest to understand dark matter. Yet, as is so often the case in the realm of physics, there remains a lot of work left to be done.

This is certainly also true for the related quest to prove the existence of axions. Given their promise as a dark matter candidate, and as a potential solution to other important issues such as the strong CP problem, we have every reason to invest time in researching these elusive particles. Fortunately, efforts dedicated toward the discovery of axions are at an all-time high. Whether through laboratory-based detectors, astronomical observations, or innovative theoretical approaches, steady advancements are bringing us ever closer to solving this fascinating puzzle.

In this thesis, I have demonstrated that the magnetospheres surrounding neutron stars provide one promising avenue for the detection of axions. Be it as a conversion site between axions and photons or as a factory for axions themselves, these environments are perfectly suited for probing the axion's subtle interactions. Furthermore, this is still an incredibly young field of study, with ample room for development. Improvements can for example be made by enhancing sensitivities with future telescopes, performing analyses involving larger volumes of data (both old and new), and increasing our understanding of the magnetosphere. There are strong indications that axions are part of our Universe; they just need to be found. Easier said than done of course, but with new laboratories such as neutron stars at our disposal, we might be closer to success than ever before.