Coherent radiation via synchrotron cooled electron cyclotron maser emission

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Observations of compact objects such as pulsars and magnetars showcase clear signs of highly coherent radiation processes with extraordinarily high brightness temperatures that are currently unexplained. In particular, the discovery of Fast Radio Bursts (FRBs) [1] and the recent confirmation of the origin of an FRB from the magnetosphere of a magnetar [2] point towards the need to further understand coherent plasma radiation processes and their onset. One candidate to explain such coherent signatures is the electron cyclotron maser instability (ECMI), which is capable of generating intense and coherent electromagnetic radiation in magnetised plasmas [3]. For this instability to occur the plasma momentum distribution function must depict inverted Landau electron populations. Recent work has shown this occurs through synchrotron cooling, e.g. with a strong B field compatible with pulsars and magnetars, which leads to ring momentum distributions [4]. The generation of these rings relaxes the requirements for ECMI to operate around compact objects significantly [5]. We expand on these results by studying the onset and development of the ECMI after the ring formation [4] and the ensuing radiation emission process. Our analytical results, obtained from quasi-linear diffusion theory, determine the radiation signatures from the synchrotron-cooled rings; the radiation is characterised by pulsed radiation in small frequency bands centered around the cyclotron frequency and harmonics. These analytical results are confirmed with particle-in-cell simulations, including classical and quantum radiation reaction [7, 8], performed with OSIRIS [9].

References

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