Synchrotron Emitting Komissarov Torus with Magnetic Polarization around Kerr Black Holes

Juan Manuel Velásquez Cadavid†
Grupo de Investigación en Relatividad y Gravitación (GIRG)
Universidad Industrial de Santander (UIS)
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Introduction

Accretion disks are a great mechanism for determining the properties of the space-time in the vicinity of a black hole. The radiation coming from these objects changes depending on the material that compose it, as well as the emission mechanisms that occur inside the disk. In particular, it is believed that magnetic fields present in accretion disks could play an important role in both disk morphology and radiative processes. In this work it is examined the impact of magnetic polarization on the intensity map from a magnetized torus around a Kerr black hole as well as on its flux profile.

†e-mail: juan2208056@correo.uis.edu.co

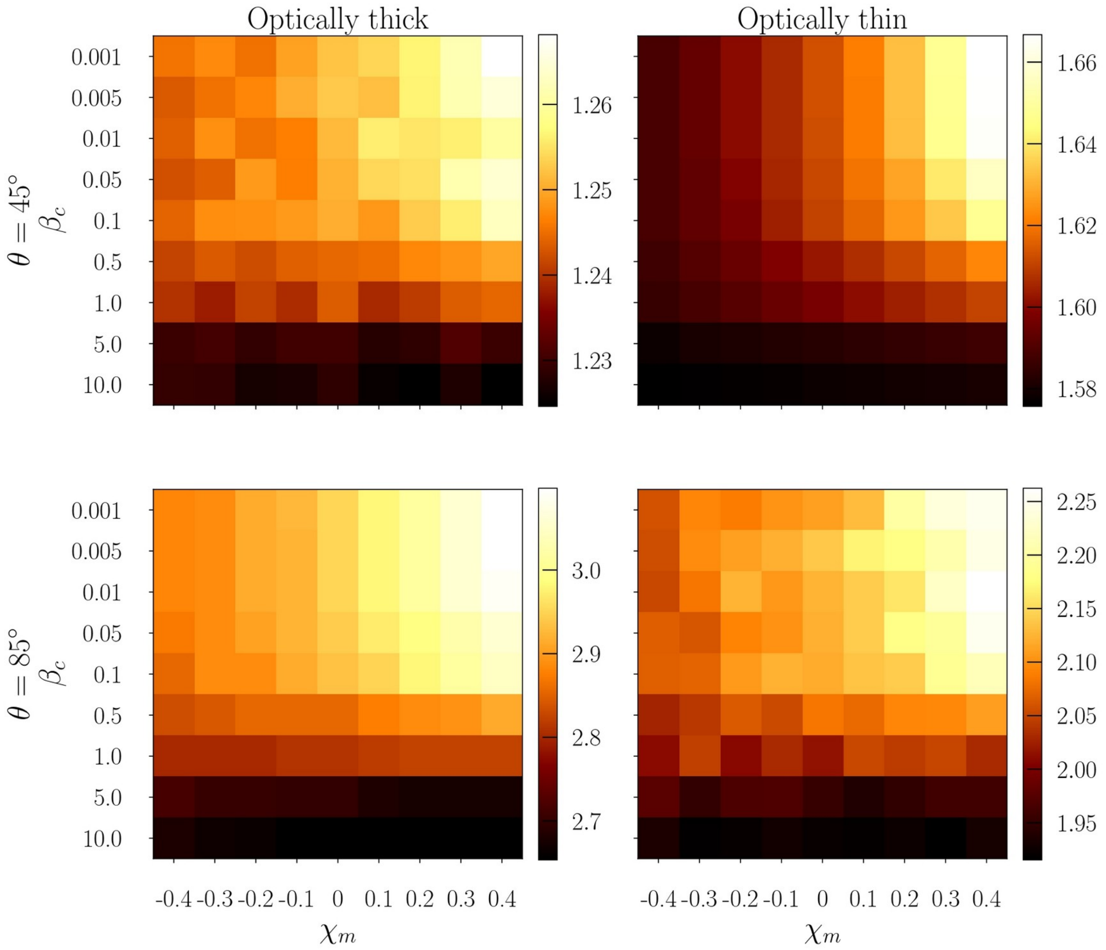
Space of parameters

The intensity observed from the radiation emanating from an accretion disk was calculated as a function of the magnetization parameter and the magnetic susceptibility. In addition, the behavior of the intensity for two types of accretion disks is shown: one optically thick and the other optically thin for two different angles.

χ_m → Magnetic susceptibility

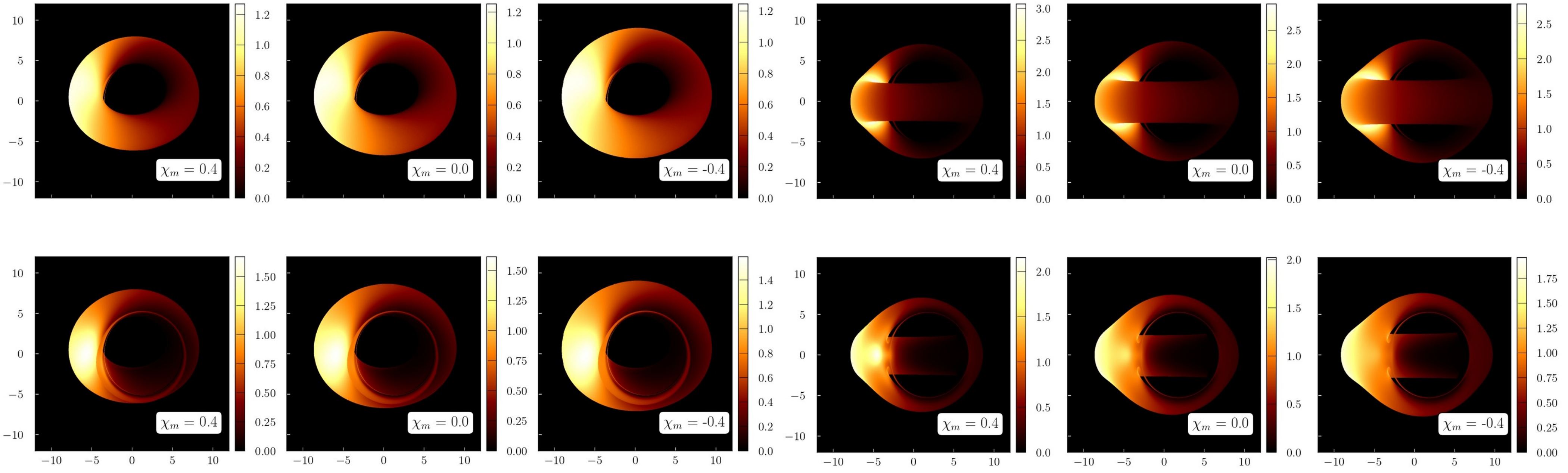
β_c → Beta-plasma

$a = 0.9$ → Black hole spin parameter

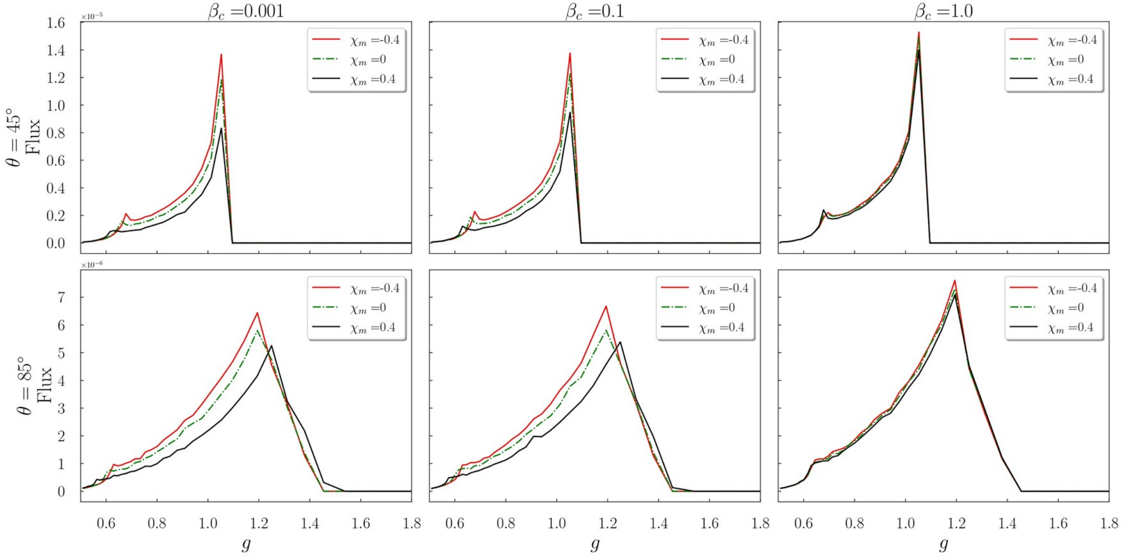


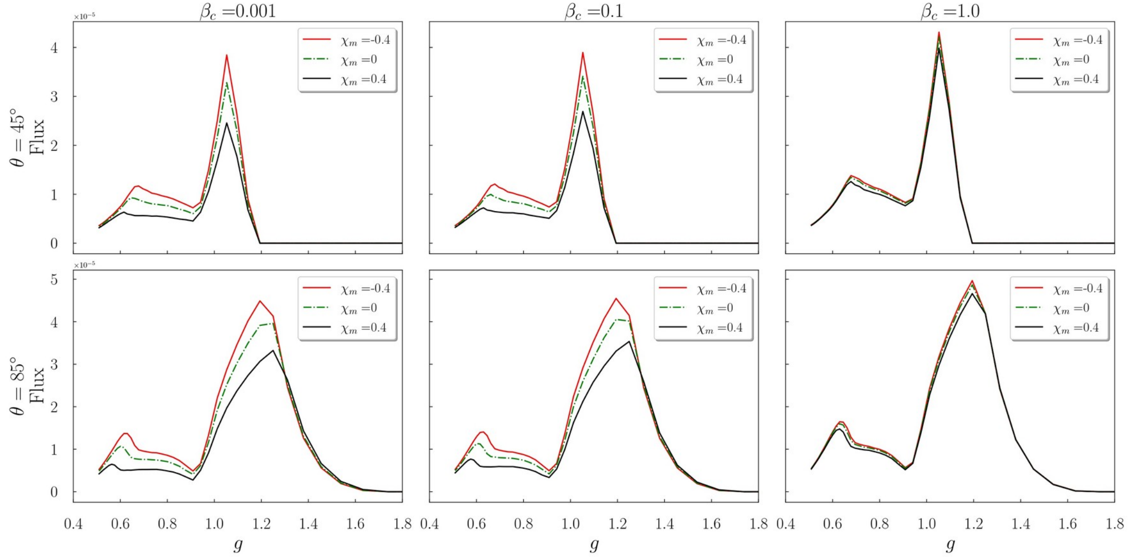
$\chi_m > 0$ → Paramagnetic material

$\chi_m < 0$ → Diamagnetic material



Paramagnetic disks emit a higher intensity compared to diamagnetic disks, as well as the more magnetized the disk is (small beta-plasma). Magnetic susceptibility also changes the morphology of the torus, making it more compact the more paramagnetic the disk is, and larger the more diamagnetic it is. Optically thick disks generate "self-eclipsing" because photons are emitted only from the surface of the disk, while optically thin disks allow the shadow of the black hole to be seen through the material.





Observed fluxes

The emission lines correspond to the observed flux as a function of the emitted frequency. The flux emitted by diamagnetic materials has a higher peak compared to the paramagnetic case and without polarization due to the increase of the optical path inside the disk due to the broadening produced by the magnetic polarization. The fluxes for optically thick disks (upper graph) change with respect to optically thin disks (lower graph), highlighting in the latter the peaks corresponding to the red shift (peaks to the right) and the blue shift (peaks to the left).

Remarks

- Both the degree of magnetization and the magnetic susceptibility affect the map of intensities coming from an accretion disk around a black hole.
- Magnetic polarization could have potentially observable effects according to the observed flux, since magnetic susceptibility amplifies the observed flux for diamagnetic materials and reduces it for paramagnetic materials in contrast to almost no polarization.
- From the profiles, it appears that the paramagnetic materials red-shifted the maximum flux peak.
- The tilt angle affects both the intensity map and the observed flow profile. The optical depth of the material also affects them.