MAGNETIC DIPOLE MOMENT OF SPINNING DISK

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Reference: Griffiths, David J. (2007) Introduction to Electrodynamics, 3rd Edition; Prentice Hall - Problem 5.35.

Here's another example of the magnetic dipole. We have a circular disk with surface charge density σ that is rotating at an angular speed ω. We can use the result for the magnetic dipole moment of a circular loop and integrate this to get the dipole moment for the disk.

The moment for the loop is

$$\mathbf{m} = \pi I r^2 \hat{\mathbf{z}} \tag{1}$$

The linear speed of a loop of radius r is $r\omega$ so the current at that radius is $dI(r) = r\omega\sigma dr$. The total dipole moment is then

$$\begin{aligned} \mathbf{m} &= \pi\omega\sigma\hat{\mathbf{z}}\int_0^R r^3 dr & (2)\\ &= \frac{\pi R^4}{4}\omega\sigma\hat{\mathbf{z}} & (3) \end{aligned}$$