Magnetic dipole fields and current loops

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3 Numerical analysis and graphics

3.1 Dipole field (far field of magnetic current loop)

$$\mathbf{A} = \frac{I\,a^2\,\mu_0}{4(X^2+Y^2+Z^2)^{\frac{3}{2}}}\begin{bmatrix}-Y\\ X\\ 0\end{bmatrix} \tag{41}$$

$$\boldsymbol{\omega} = \begin{bmatrix}-\frac{z^2-2y^2+x^2}{x\,(z^2+y^2+x^2)}\\ -\frac{z^2+y^2-2x^2}{y\,(z^2+y^2+x^2)}\\ \frac{3z}{z^2+y^2+x^2}\end{bmatrix} \tag{42}$$

$$\mathbf{B} = \frac{I\,a^2\,\mu_0}{4(X^2+Y^2+Z^2)^{\frac{5}{2}}}\begin{bmatrix}3XZ\\ 3YZ\\ 2Z^2-X^2-Y^2\end{bmatrix} \tag{43}$$

$$\boldsymbol{\nabla}\times\mathbf{B} = \mathbf{0} \tag{44}$$

Figs. 1-3

3.2 Field of a magnetic current loop

Figs. 4-7

3.3 Constant magnetic field from non-constant potential

$$\mathbf{A} = \frac{B_0}{4}\begin{bmatrix}-Y\\ X\\ \frac{Z^3}{XY}\end{bmatrix} \tag{45}$$

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$$\boldsymbol{\omega} = \begin{bmatrix} -\frac{1}{X} \\ -\frac{1}{Y} \\ 0 \end{bmatrix} \tag{46}$$

$$\mathbf{B} = \begin{bmatrix} 0 \\ 0 \\ B_0 \end{bmatrix} \tag{47}$$

$$\boldsymbol{\omega} \times \mathbf{A} = \frac{B_0}{2} \begin{bmatrix} -\frac{Z^3}{2XY^2} \\ \frac{Z^3}{2X^2Y} \\ -1 \end{bmatrix} \tag{48}$$

$$\boldsymbol{\nabla} \times \mathbf{A} = \frac{B_0}{2} \begin{bmatrix} -\frac{Z^3}{2XY^2} \\ \frac{Z^3}{2X^2Y} \\ 1 \end{bmatrix} \tag{49}$$

$$\boldsymbol{\nabla} \times \mathbf{B} = \mathbf{0} \tag{50}$$

$$\boldsymbol{\nabla} \times \mathbf{B}_2 = -\frac{B_0}{2} \begin{bmatrix} \frac{3Z^2}{2X^2Y} \\ \frac{3Z^2}{2XY^2} \\ \frac{Z^3(X^2+Y^2)}{X^3Y^3} \end{bmatrix} \tag{51}$$

Figs. 8-12

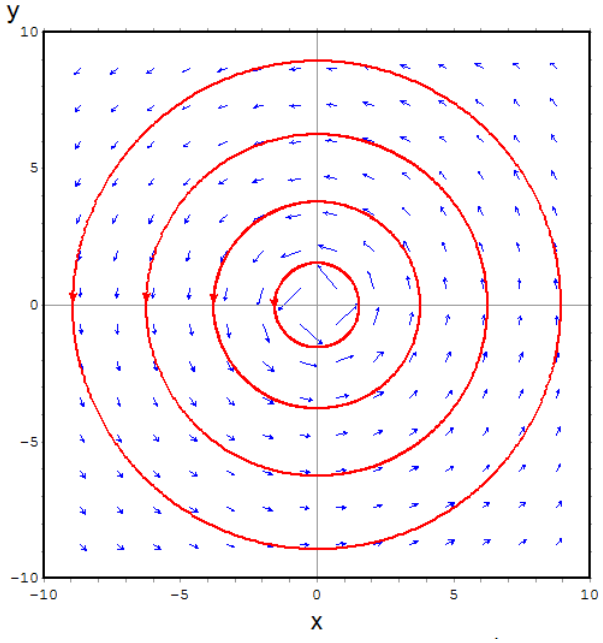

Figure 1: **A** field of far field dipole, XY plane.

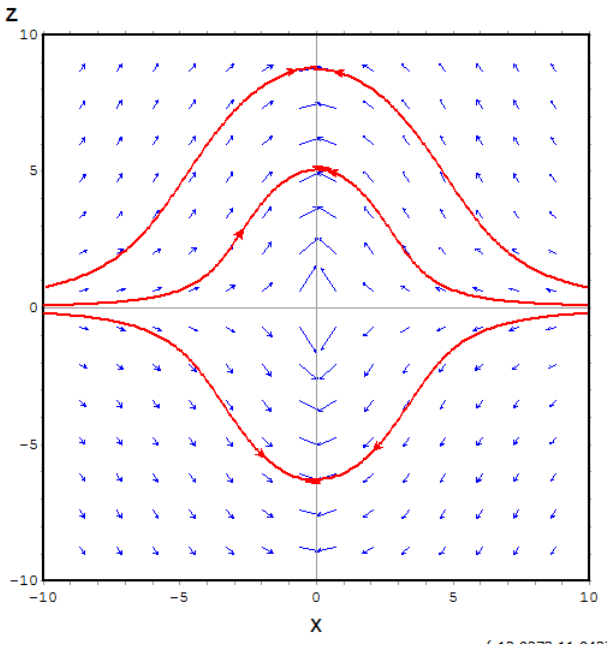

Figure 2: $\boldsymbol{\omega}$ field of far field dipole, XZ plane.

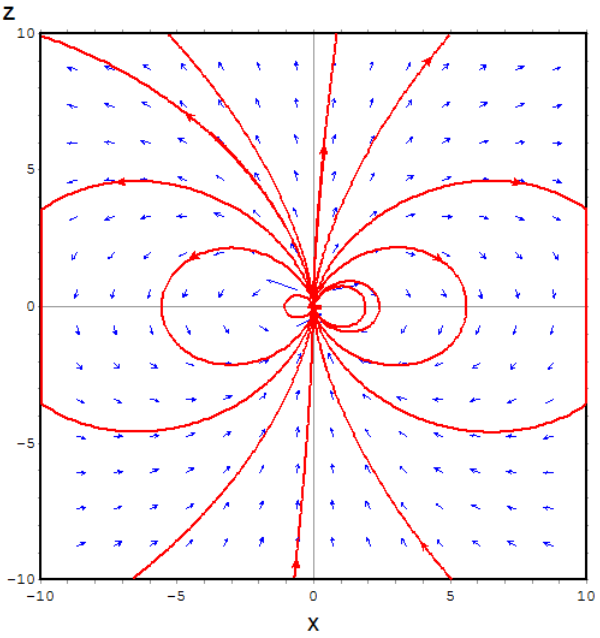

Figure 3: **B** field of far field dipole, XZ plane.

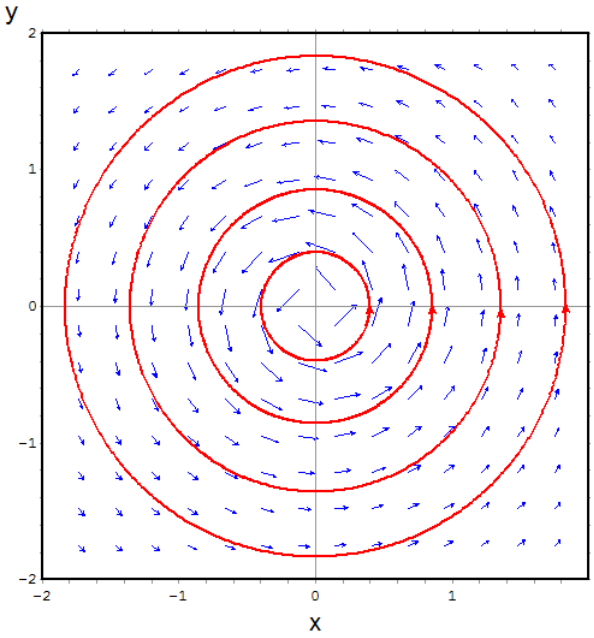

Figure 4: **A** field of magnetic current loop, XY plane.

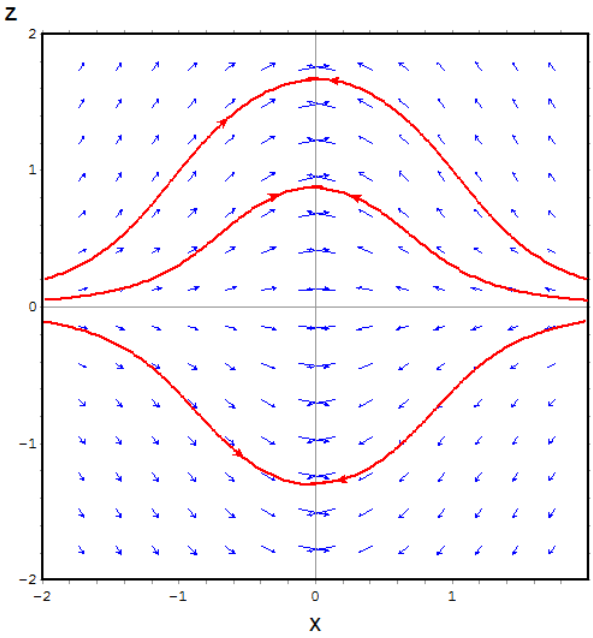

Figure 5: $\boldsymbol{\omega}$ field of magnetic current loop, XZ plane.

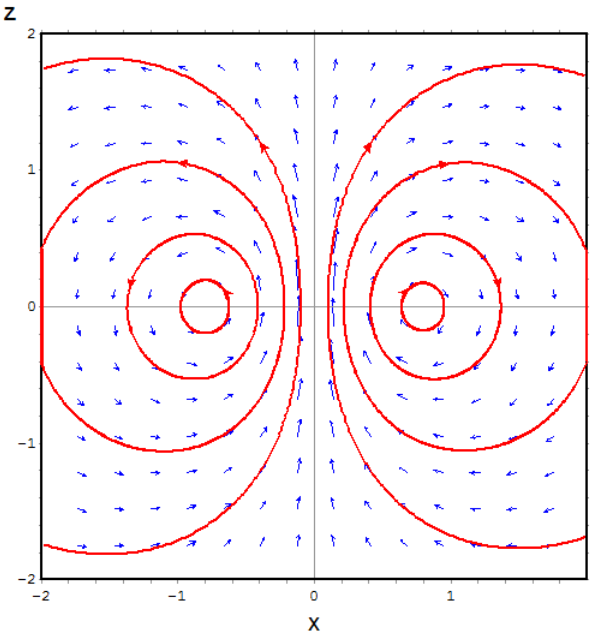

Figure 6: $\mathbf{B}$ field of magnetic current loop, XZ plane.

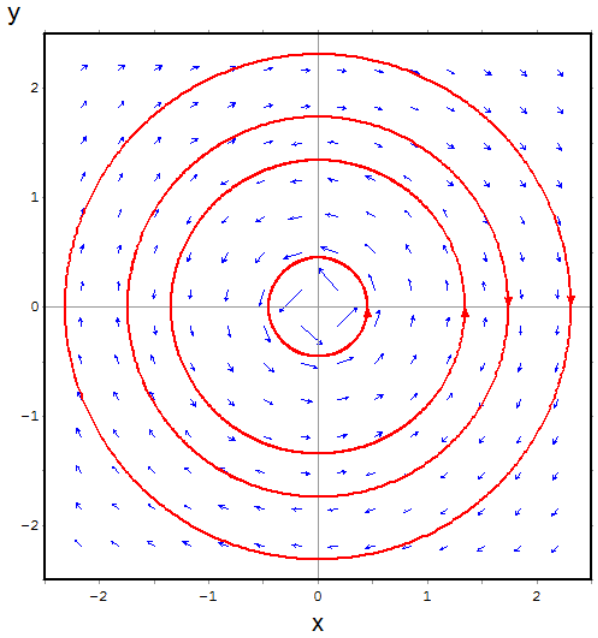

Figure 7: Current density **J** of magnetic current loop, XY plane (notice alternating directions).

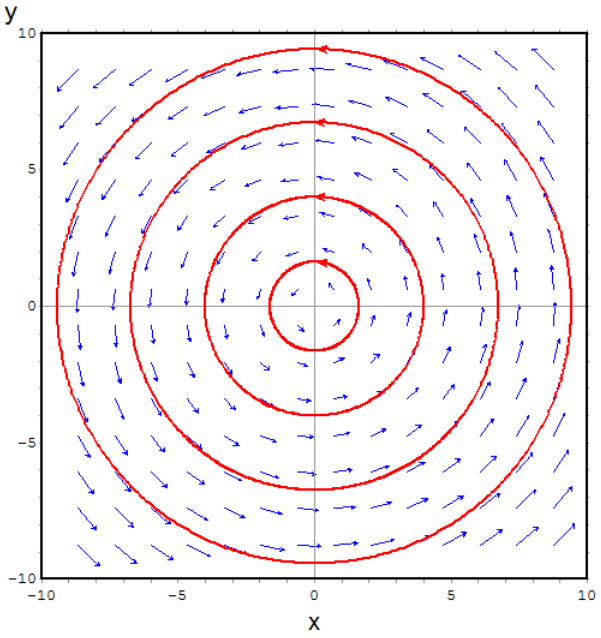

Figure 8: **A** field of special case, XY plane with $Z = 1$.

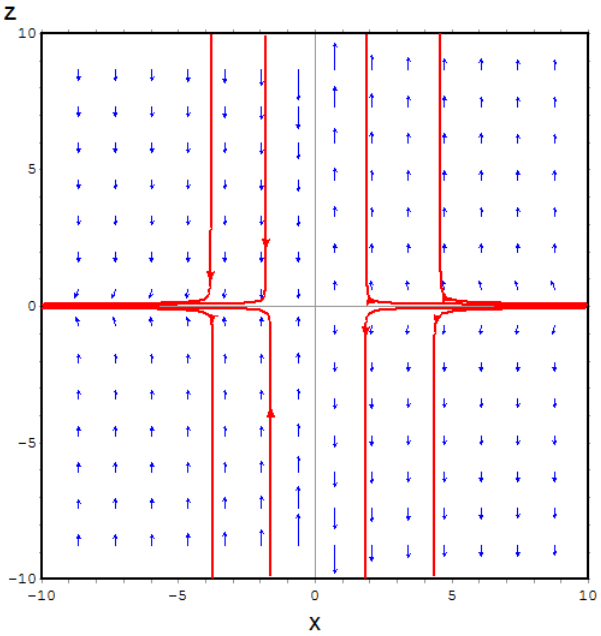

Figure 9: **A** field of special case, XZ plane with $Y = 0.1$.

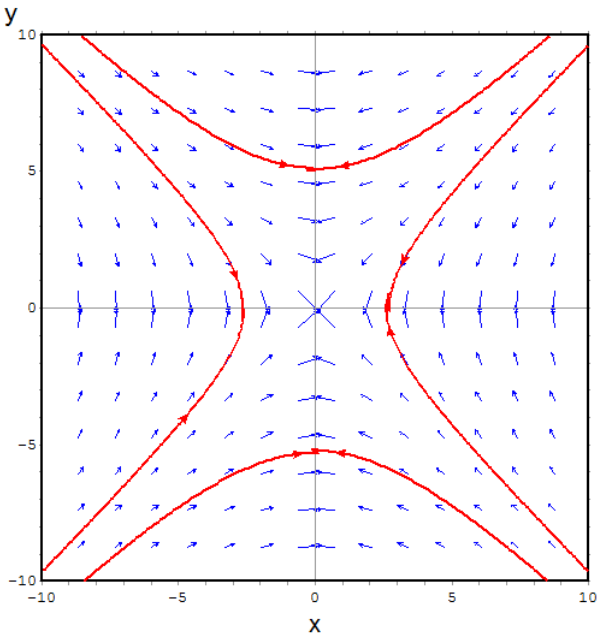

Figure 10: $\boldsymbol{\omega}$ field of special case, XY plane.

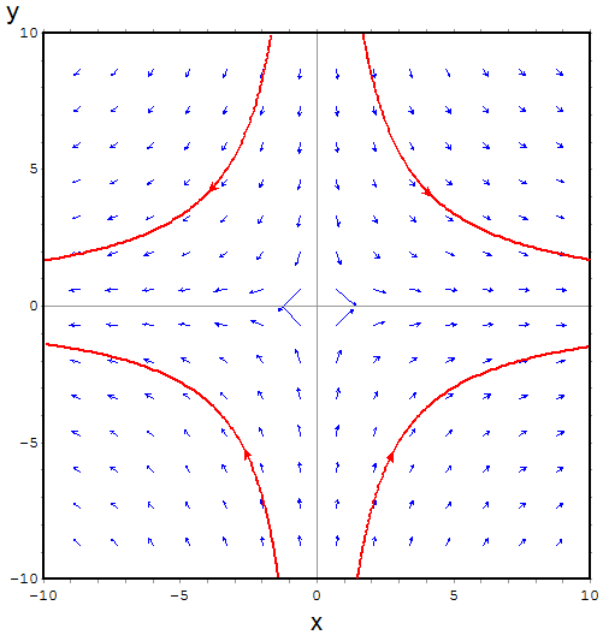

Figure 11: Magnetic field component $\boldsymbol{\omega} \times \mathbf{A}$, field of special case, XY plane with $Z = -1$.

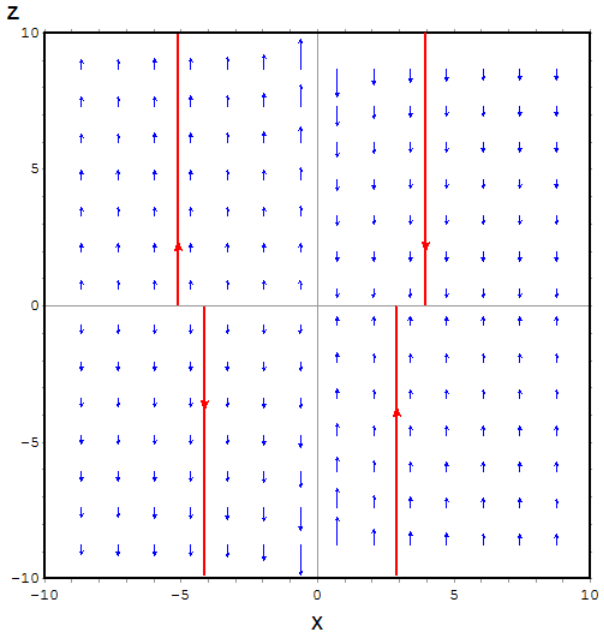

Figure 12: Current component $\mathbf{J}_2$, field of special case, XZ plane with $Y = 0.1$.