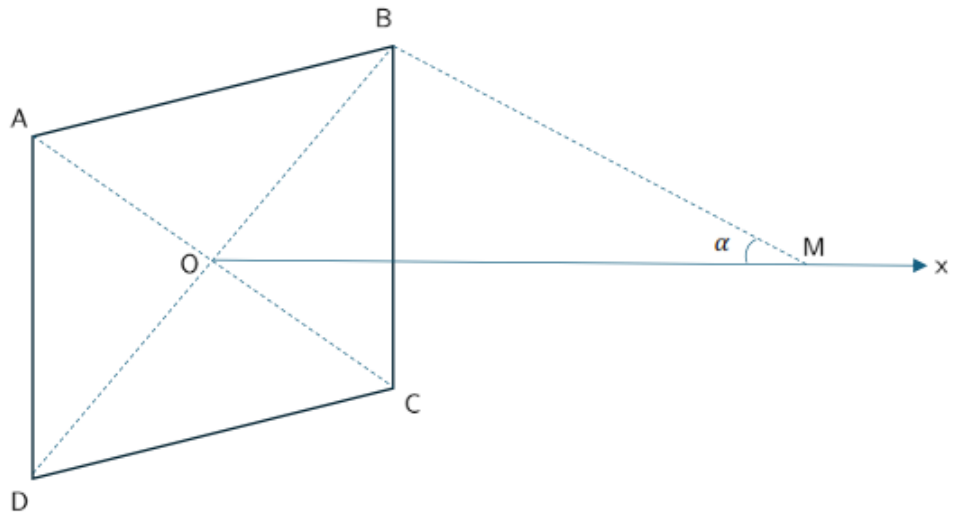
TD3: Electromagnetism

Symmetry in discrete charge distributions

Exercise 1: Calculation of the electrostatic field on a symmetry axis



Four identical point charges $q > 0$ are placed at the vertices of a square of side L, as shown in the above diagram. We are interested in the total electrostatic field created by the charge distribution at a point M located on the symmetry axis perpendicular to the plane of the square, passing through its center. The distance between M and the center of the square O is x.

1. What can be said about the total electrostatic field if point M is at O, that is if $x = 0$?
2. Add on the diagram the electrostatic field vectors created by each charge at point M.
3. What can be said about the total electrostatic field at point M when $x > 0$? Explain using a diagram or geometric arguments.
4. Show that the total electrostatic field at point M is given by the expression

$$\vec{E}_{tot}(M) = \frac{4kqx}{\left(x^2 + \frac{L^2}{2}\right)^{3/2}} \vec{u}_x$$

5. Calculate the norm of the total electrostatic field at its maximum, which occurs at $x = \frac{L}{2}$.
6. How can the above expression be simplified when $x \gg L$?
7. Plot the norm of the total electrostatic field as a function of x.