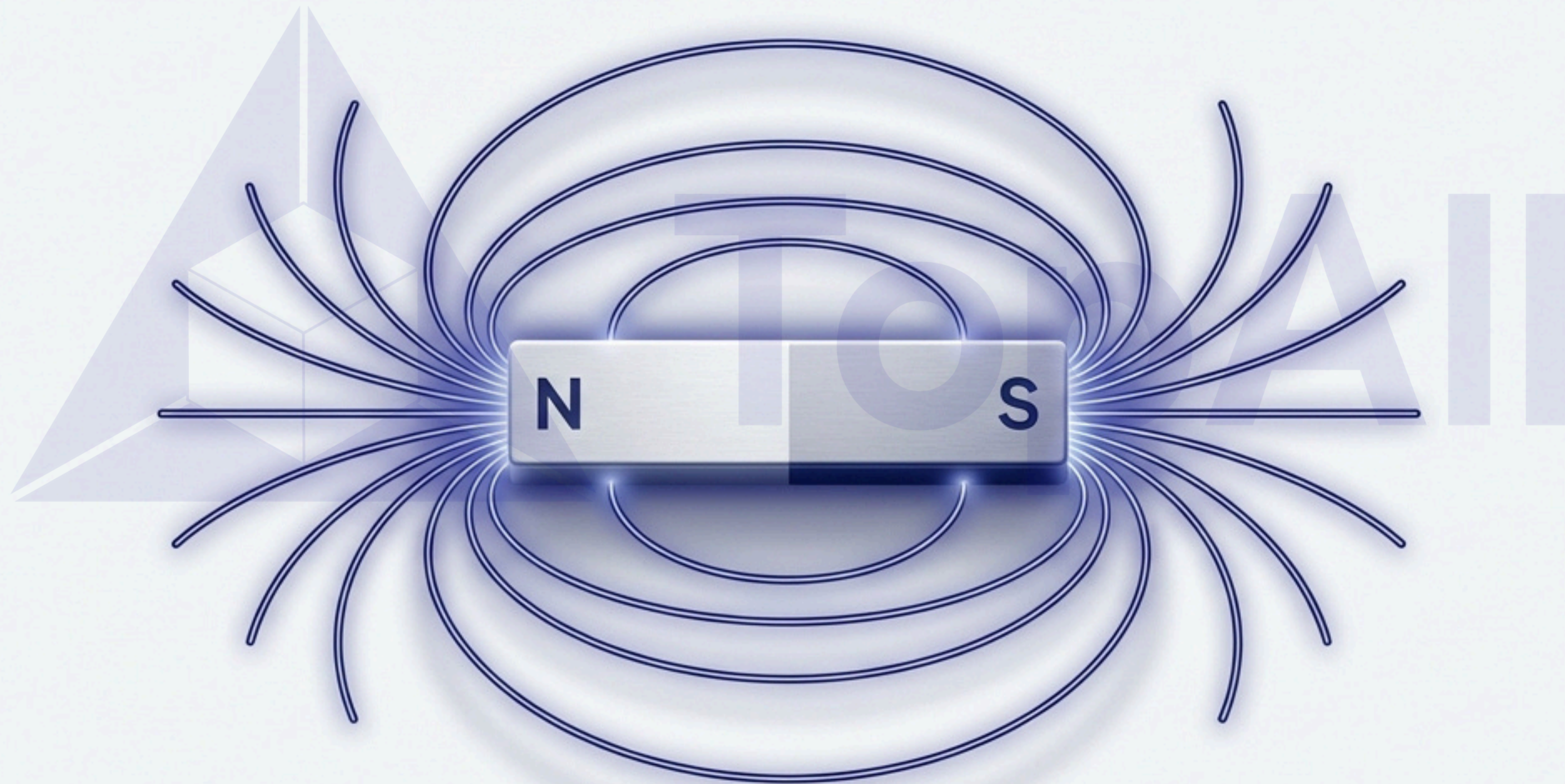
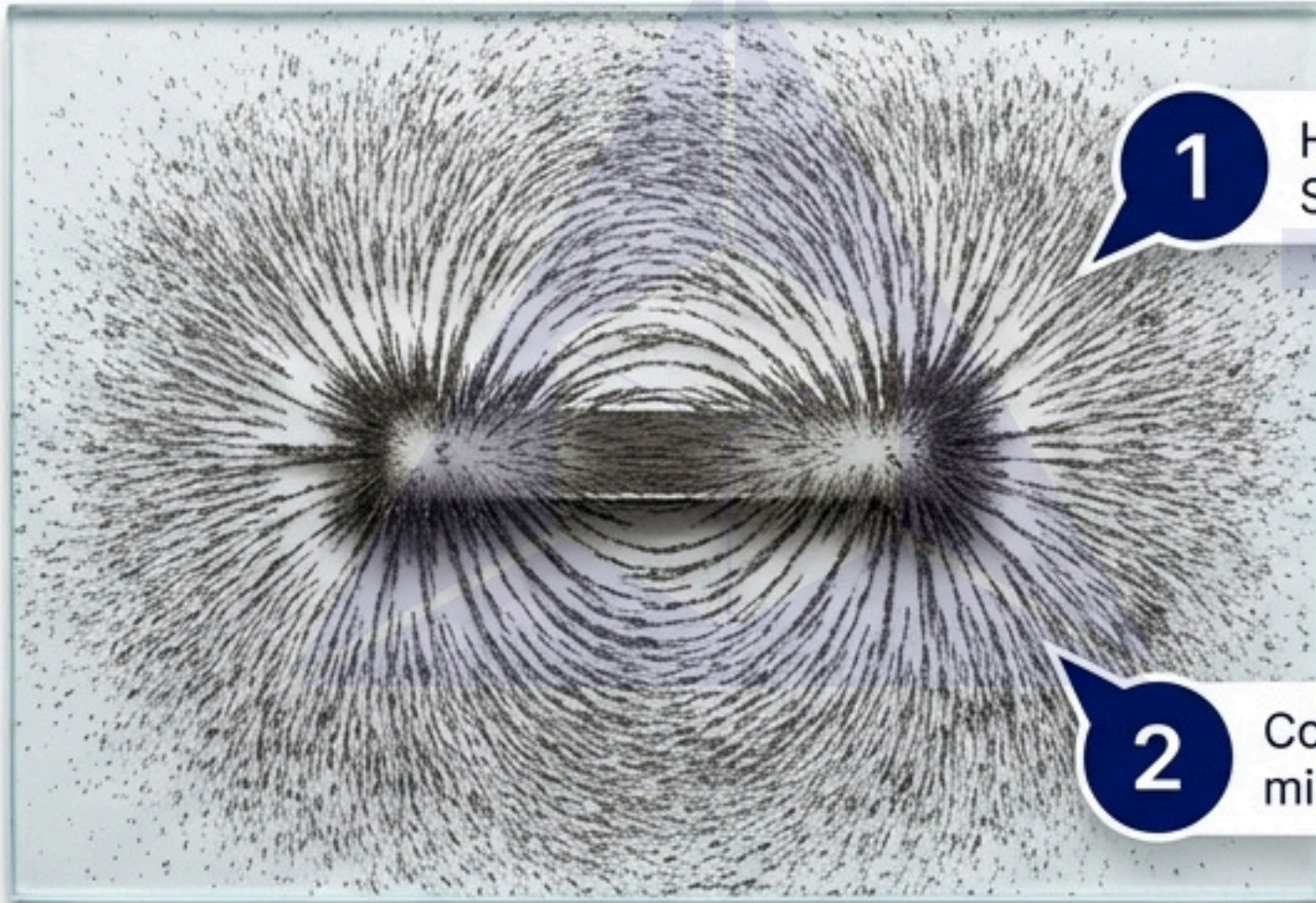


Magnetic Field Lines



From Iron Filings to Field Lines

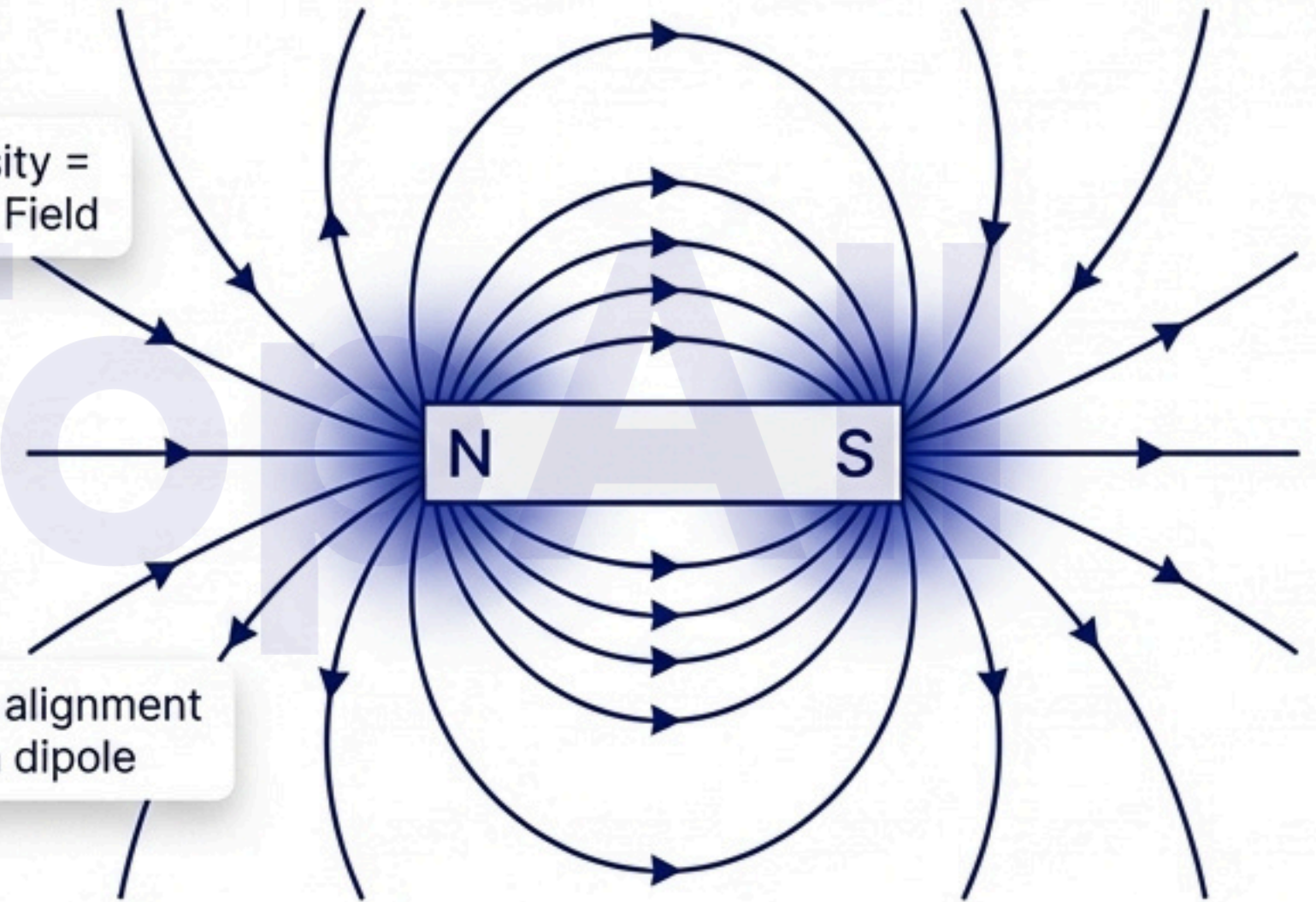
The Observation



1 High Density = Strongest Field

2 Continuous alignment mimicking a dipole

The Abstraction



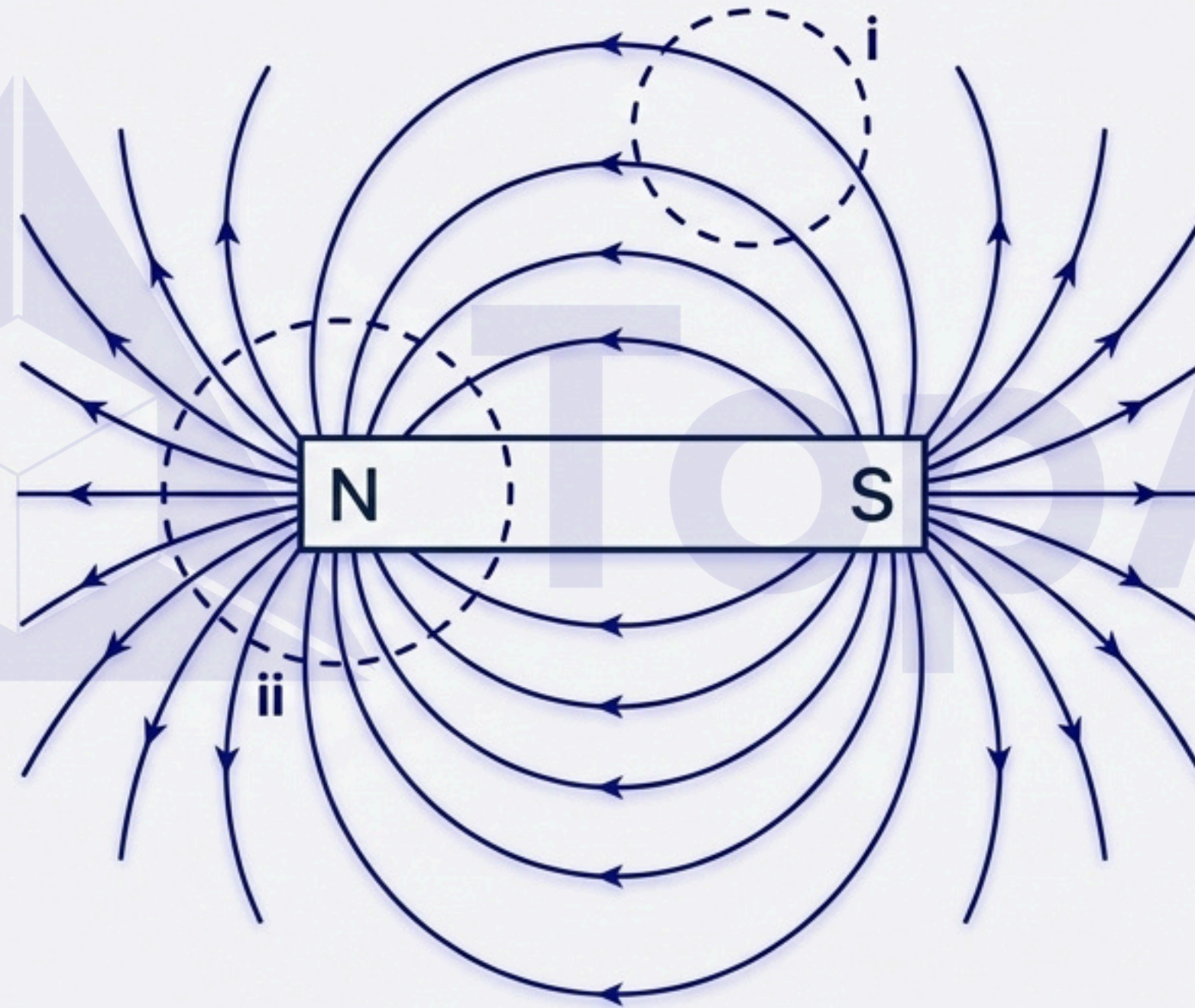
The physical pattern of iron filings proves the magnet possesses two poles, intuitively visualizing the invisible magnetic field.

Field Lines of a Bar Magnet

Key Geometry: Continuous Closed Loops

Outside the Magnet.

Lines emerge from the North pole and merge into the South pole.



Inside the Magnet.

Lines travel from the South pole back to the North pole to complete the circuit.



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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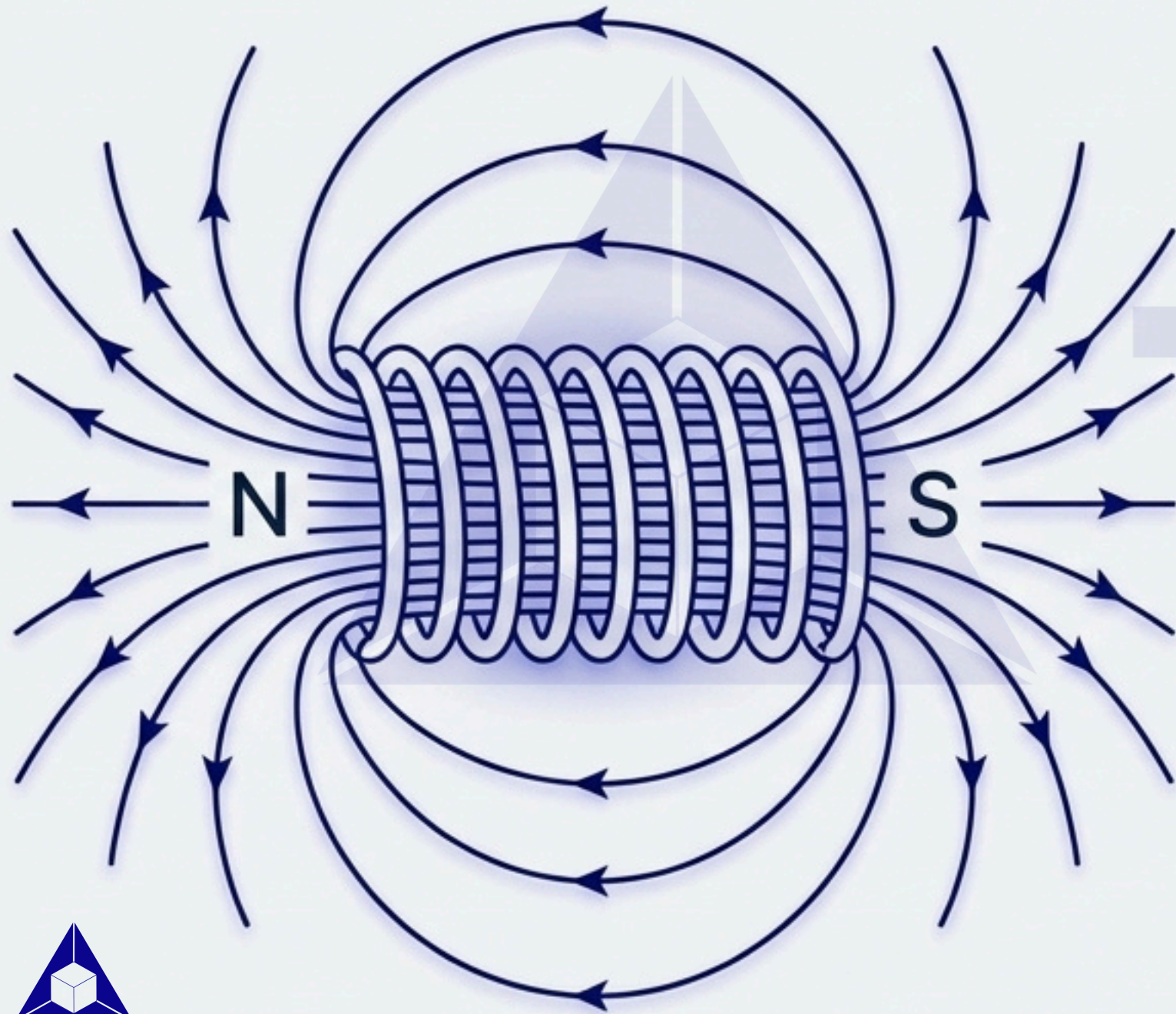
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Field Lines of a Solenoid



The Bar Magnet Analogy

Cutting a bar magnet is like cutting a solenoid—the field lines remain continuous, emerging from one face and entering the other.

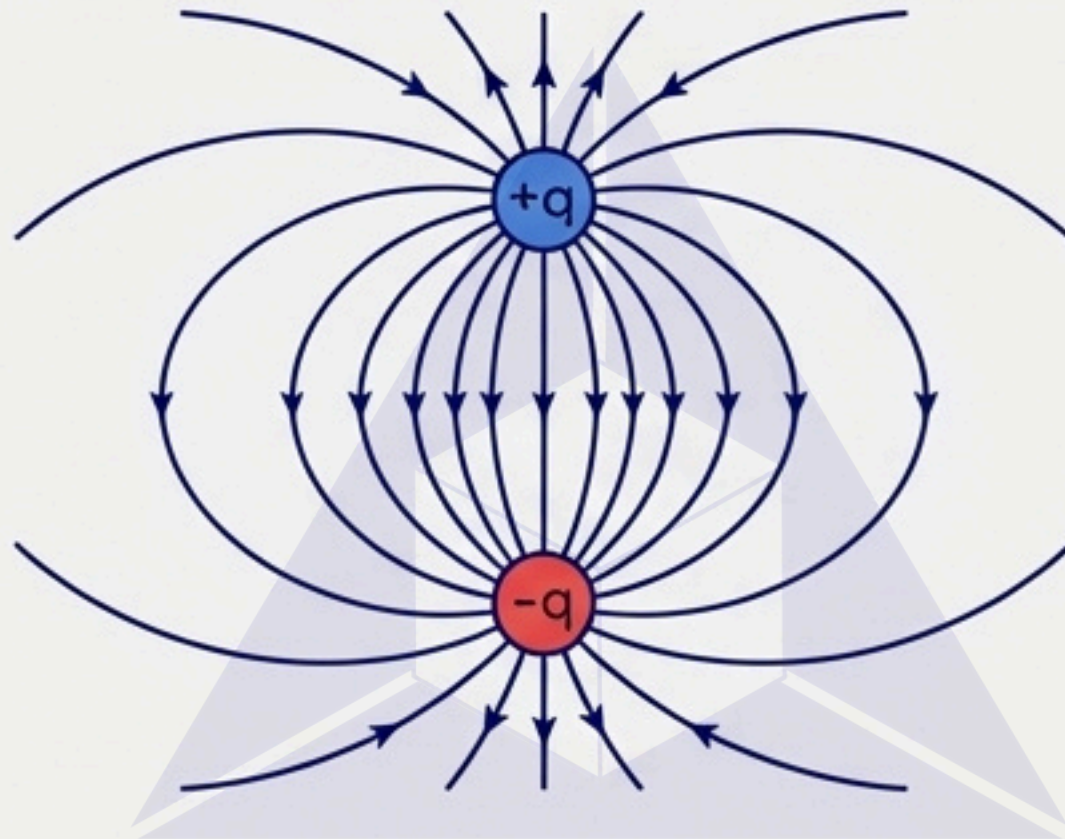
Far axial magnetic field equivalence:

$$B = \frac{\mu_0}{4\pi} \frac{2m}{r^3}$$

At large distances, the solenoid field is identical to a bar magnet.

Comparison with Electric Dipole

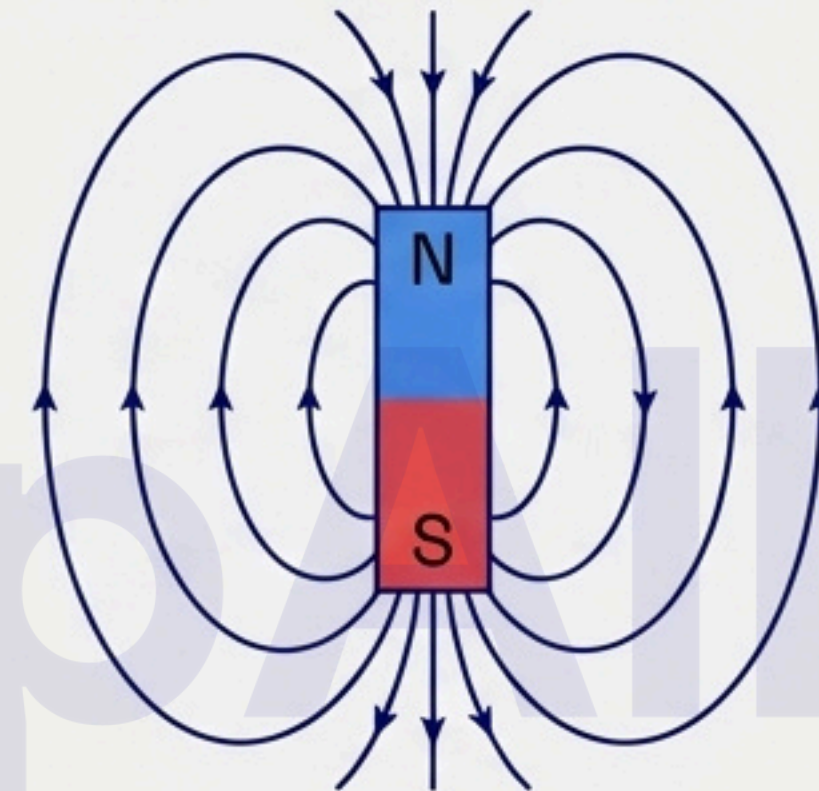
Electric Dipole



Open Loops

- Field lines begin at $+q$ and end at $-q$ (or escape to infinity).

Magnetic Dipole



Closed Loops

- Field lines never terminate.

The Crucial Difference: Unlike electric charges, isolated magnetic monopoles do not exist. Therefore, magnetic field lines must form continuous loops.

Properties of Magnetic Field Lines



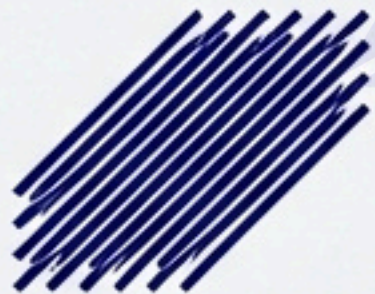
1. Continuous Closed Loops.

They form endless circuits, unlike electric field lines which have distinct start and end points.



2. Tangent = Direction.

The tangent drawn to the field line at any given point represents the exact direction of the net magnetic field B at that point.



3. Density = Strength.

The larger the number of field lines crossing per unit area, the stronger the magnitude of the magnetic field.



4. Lines Never Intersect.

If they did intersect, the magnetic field would have two unique directions at a single point, which is physically impossible.



DO NOT CONFUSE

Magnetic Field Lines $\neq$ Lines of Force

In electrostatics, field lines indicate the trajectory of force on a charge. **In magnetism, this is false.** Magnetic field lines do *not* indicate the direction of the force on a moving charge.

(Recall: Magnetic force is perpendicular to B).



You've Learned the Theory.

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