

Geomagnetic Induction.

- ① Seed Magnetic field go through Earth's Core!
- ② This induces an Electric field in Earth's Core
- ③ This Electric field Induces the Geomagnetic field
- ④ The Geomagnetic field Induces back the Electric field.
- ⑤ The Electric field induces back the Geomagnetic field!

Question : ① We know the Earth's Core to be molten metal but doesn't the motion of molten metal cause an electric field?

Induction Equation (: Moving fluid through a B-field induces an E-field.)

Where does the Electric field Originate?

From the interaction of the seed

⇒ The flowing conducting media did not have an E-field before.

The moving charge through the magnetic field induced a current / E-field.

or * From the flowing molten iron itself.

Then Where is the need for the Seed M-field.

Doesn't the Convection provide the current or even the Coriolis Effect?

Like current carrying conductor through m field → or a motor.
or $\vec{F} = B \times \vec{v}$.

→ force on charge
cause the electric field.
(Lorentz-force)

* What is occurring in the Core?

① We know that the Core is molten i.e. It is a liquid.

↓
But A liquid Can be at rest. → No moving liquid is like a copper wire under no tension. The charge carriers are there but they are not moving.

↓
How is the liquid moving

↓ In our case, since there is a battery to create a p.d and move the charge carriers in the core, there must be another force acting on the charges to move them and set up an E-field.

→ One requirement for the

Lorentz - force to be exerted on the charges is to have a MOVING charge through a magnetic field.

It is a Potential Difference which makes them move.

↓
The p.d exerts a force:
 $F = eV$ on each electron.

↓ Creates an E-field!

The movement of
the charges is brought or
about by Compositional & Thermal
Convection - Sinking of denser
Material into the core.

The Coriolis Effect
causes the fluid
to rotate (Arrange
in Taylor Columns)

??

* Wikipedia says
m-field is induced
& maintained by convection
of molten iron in the outer
core

It seems to me that
the Coriolis Effect arranges
the convectional currents
into rolls!
(They both are required for
the formation of Taylor Columns)

What Maintains
the Convection?

↳ Inner Core
Heat (like
boiling water)

+ Compositional
Convection
(ρ differences)

But does the movement
of this liquid NOT generate
a current??

THE BIG QUESTION

↳ NO!!!

→ The rotating fluid w/o a magnetic field acts as rotating an armature from a dynamo in free space.

↳ IT DOES NOTHING !!

This is where the Lorentz force comes in! move charges etc...

The Sun can act as the magnets

↳ The rotating fluid cuts magnetic flux from the sun inducing an Electric field.

↓
The E -field need not go in the direction of the electric field.

→ Faraday's Law of Induction

$$\nabla \times E = - \frac{dB(t)}{dt}$$

$$\text{or } \boxed{\nabla \times E = - \frac{\partial B}{\partial t}}$$

↓
Ampère's Law

A (conductor) carrying a wire produces a B-field which circulates the wire.

$$\nabla \times \mathbf{H} = - \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J}_f$$

Moving Charge

Produces Magnetic Field.

→ Solenoid.

Solar fusion

Combining Hydrogen to Produce Helium

↳ But differences in Helium nuclei & Protons

↳ mass = $\boxed{\Delta E = \Delta m c^2}$

↳ Difficult to bring the Protons together due to electrostatic repulsions → At high Pressure

& T, Strong force acts to bring the Particles together for fusion.

↓ This is related to the Nuclear Binding Energy.

↓ Brings 2 protons close together due to high pressure & temperature in the Sun's core.

↓ Residual Strong Force (at order of femto meters) offset Coulomb force (repulsive) & cause the 2 protons to bind releasing energy (Δmc^2) in the process

↳ This thermal energy maintains the Sun hot for further reactions.

Now, Iron has maximum binding energy per nucleon

↓ A lot of energy is released when forming the nucleus (^{56}Fe is a very stable nuclide)

Why?

For 56 nucleides, the Strong force is at its Sweet (maximum) spot able to hold the nucleons together w/o much effect of Coulomb force.

↳ The Strong force has a Maximum limit on nucleides.

As we go through the Periodic table, the nucleon grows & the effect of Strong force on the whole nuclei starts to be reduced.

How does this relate to increasing binding energy per nucleon?

Trend: As nucleon n_0 increases, $B \cdot E/N$ also increases
i.e. More energy is released when forming the nucleon

→ or More energy is required to break the nucleide apart

Why(??)

→ The nucleide becomes more stable.

→ But if it is so favourable, Why does our sun not do it? → Our sun does not have enough Temperature/Pressure.
→ It can do oxygen fusion tho...

→ Why nucleides have high stability?

• What is the Price of this high stability?

→ We know ^{56}Fe is stable due to high Proportion of Strong Nuclear force to relatively less effective Coulomb force!

⇒ As we go up the curve (upto ^{56}Fe)
Strong Force becomes more efficient.
↳ BUT, look at the graph of Strong nuclear force.

& Least average mass per nucleon.

↓
Greater mass defect due to higher $\underline{\underline{\Delta m C^2}}$

↳ Highest Energy Release.

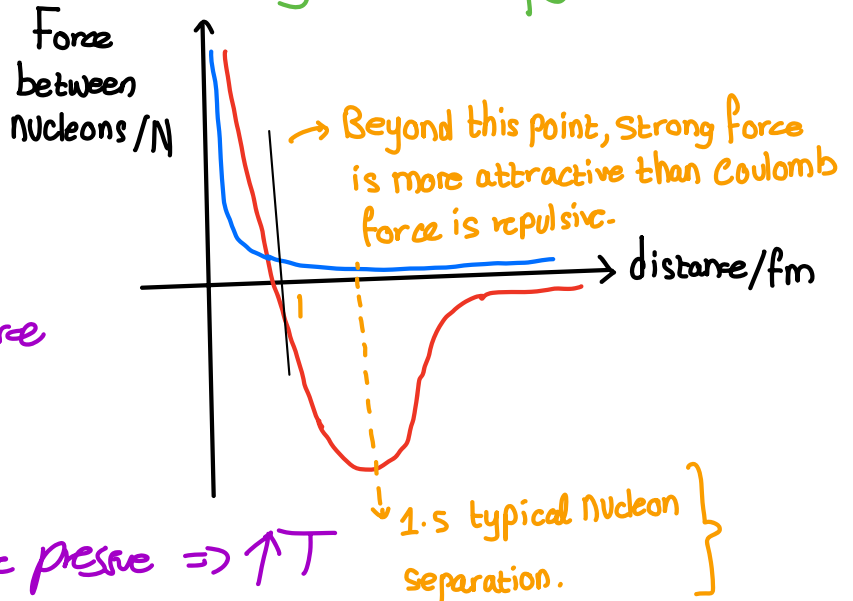
Most efficiently bound to the nucleus

+ Coulomb potential

More Work must be done to bring the nucleides in the range of Strong nuclear force.

As nuclear size increases, the coulomb potential between the nuclei increases ← due to increasing force of repulsion from the charges.

→ Coulomb repulsive force must be opposed to bring the 2 nucleides close enough for strong force to take over.



Larger stars have more pressure $\Rightarrow \uparrow T$
to allow the particles to get closer
together to be able to fuse lighter elements
to harvest energy!