Selected Problems

- Space radiation (Galactic Cosmic Radiations and Solar Events Particles) exposure affect significantly the human health.

- Space suit size problem (especially for women astronauts).

- High Cost of space suits (around $12 million).
Space Radiations are composed of two major components -

- **Gamma Cosmic radiations (GCR)**
  - Consists of ionized H, He, as well as high atomic number energetic particles (HZE) such as Fe+26, O+8, and C+6 [1]
  - Always present and very energetic
  - Composed of many different elements
  - Intensity varies with Solar Activity
  - Intensity varies throughout 11 year Solar Cycle

- **Solar Electronic Particles (SEP)**
  - Consists mainly of protons and electrons
  - Infrequent
  - Very intense with rapid onsets
Effects on Human Health

Acute effects:
- Nausea, vomiting and Fatigue
- Central nervous system effects (motor and behavioral changes)

Chronic effects:
- Carcinogenesis (leukemia, gastrointestinal, lung, brain cancer)
- Vision impairment (cataracts)
- Cardiac disease
Earth's magnetosphere, the first layer of protection against solar flares, whisks away the flare's charged particles. Due to the effects of the solar wind, the magnetosphere has a compressed, bulbous side that faces the sun, a dip near Earth's poles and a flowing tail extending away from the sun. Earth's magnetic field blocks these charged particles from most of our planet's surface, while the solar wind pushes them along to the tail of the magnetosphere. The earth has magnetic field value of 40,000 nT and we need only few hundreds of nT values to protect us from space radiation.
Solution to the SEP radiation problem
(analogous to earth)

- Space suit having magnetic field shielding created using ferromagnetic material yarn and sewing them in form of closed loops forming **confined magnetic field** around the body. Hence, protecting them from Solar Electronic Particles.

Ampere’s Circuital Law:

\[ \oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I \]

For N number of turns in coil

\[
2\pi r B = \mu_0 I \\
\Rightarrow \frac{B}{\mu_0} = \frac{I}{2\pi r} \\
\Rightarrow H = \frac{NI}{2\pi r}
\]

Source: [https://www.electrical4u.com/ampere-circuital-law/](https://www.electrical4u.com/ampere-circuital-law/)
Solution to GCR Problem

A proposed design for radiation shielding in interplanetary travel is presented with primary shielding created by a superconducting *split toroid* magnetic field and *unconfined magnetic fields* created by two deployable superconducting loops and passive shielding via *Boron Nitride Nanotubes (BNNT)*

So an experiment was performed with particles of twice the energy of the most probable GCR particles were chosen. These particles were $Fe^+2, Fe^+6, C^+6, He^+2, and H+$ with kinetic energies of 84 GeV, 18 GeV, 12 GeV, and 1.5 GeV respectively.
The particle’s velocity is directed towards the center of the crew area to maximize the amount of B-field traversed. Due to the *unconfined toroidal B-field* in the simulation, the particles are initially *redirected to a tangential path along the toroid* and some are pulled into the toroid as grazing particles. In a final design, this effect will not occur to this extent due to the toroid being a *nearly confined field*.

The total length of wire of the deployable loops and split toroid was added up to calculate a wire mass of 4.15104 kg. The total mass, including an estimate of the toroidal caps, is calculated to be 8.08104 kg by doubling the mass of the toroid wires.

A space station similar to the ISS could be designed to move between orbits of Earth, the Moon, Mars, or many other bodies using this shielding method without the need for chemical propellants by using the momentum from redirected radiation.

This Magnetically Shielded Self-Sufficient Space Station (M5S) holds potential to be a more practical method for interplanetary travel.
Current space suit

Cross section of material layup used for fabric for the arms and legs of the spacesuit.
Demo

- Coil around the glove is magnetic field
- Layers
- LEDs to show that spacesuit is on and functioning.
- Tin Foil to show the woven magnetic material.
Market for our product

We are better because we provide shield using confined as well as unconfined magnetic field.
Customers (Future Plans)

- Customers of NASA ISS Tourism 2020 will have their own customized spacesuit.
- Any Government or private organization that wants to perform space operations for an affordable price (e.g., SpaceX colonization of Mars)
- Customers can buy their suits online on e-commerce marketplace such as Amazon, Ebay etc and they will select their sizes on the basis of the dimensions extracted from their picture.

- How will they know about our product?

  Website and online marketplaces.
QUESTIONS?