SpaceGuard Blanket Initiative

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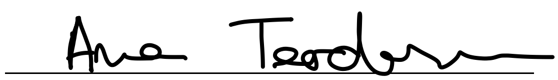

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Abstract:

As we venture into the universe, we confront the challenge of shielding ourselves from cosmic radiation. This experiment aims to design a 'blanket' using accessible materials to reduce the impact of x-rays on the human body. While electromagnetic fields can block ionized particles, they do not shield against x-rays and gamma rays. Thus, the proposed solution is a blanket that mitigates x-ray radiation and can double as a textile material.

Introduction and literature search:

The prospect of long-term space travel looms on the horizon, accompanied by a myriad of challenges. Foremost among these obstacles is cosmic radiation, which presents a formidable barrier to deep space exploration. However, it is but one of several hurdles to overcome. Despite the current imbalance where risks outweigh benefits, emerging advancements offer hope for previously insurmountable problems. One proposed solution to mitigate the effects of space radiation involves equipping spacecraft with their own electromagnetic fields. This mechanism aims to deflect ionized particles inherent to cosmic radiation. Despite its efficacy in blocking these particles, this method remains vulnerable to penetration by X-rays and gamma rays. Another concept suggests encasing the spacecraft in a substantial layer of water, leveraging hydrogen's radiation-shielding properties. Strategic placement of the crew's water supply could facilitate the creation of this protective barrier. However, this method faces practical challenges, notably the considerable weight of water and the need for replenishment–especially considering it would also be consumed by crew. NASA has made strides in radiation protection with the development of specialized vests designed to safeguard astronauts from solar radiation. Although much of the vest's specifications are classified, it appears to focus primarily on shielding against gamma radiation using hydrogen-rich polymers. Its primary objective is to mitigate the risk of radiation-induced cancers, taking a significant step toward ensuring crew safety during space missions. In summary, while the hurdles are plentiful, ongoing research and innovative strategies, such as those offered on suggested here, present promising pathways toward enhancing the safety and viability of prolonged space expeditions.

<u>Research conducted:</u>

My research focused on finding materials both practical and likeley to block radiation that were readly availible. Faraday fabric is an electromagnetic shielding material made of multiple layers that create a faraday cage. A faraday cage is a specially designed enclosure that prevents electromagnetic signals or fields from passing through its walls. It is known to have anti-static, antifungal, and antibacterial properties. Carbon fiber fabric offers stable performance with high carbon content, resilience to harsh environments, and excellent resistance to acids and alkalis. This material in many layers is known to protect against electromagnetic radiation. According to Veronika Tunakova's 2021 study on on developing and analyzing carbon-fiber reinforcements for electromagnetic shielding in epoxy composites, titled "Carbon-fiber reinforcements for epoxy composites with electromagnetic radiation protection—prediction of electromagnetic shielding ability", "the inter-yarn pores represent the apertures. All types of discontinuities (e.g., seams, ventilation holes, etc.) considerably reduce the effectiveness of the shield, while with a higher frequency, the intrinsic SE of the shield material is of less concern than the leakage through the apertures." (Tunakova). Tunakova's study shows us that in a woven state, the protection from electromagnetic radiation is diminished. Thus, with the fabric not showing signs of having x-ray protection aspects, I have chosen to remove this fabric from my prototype. Mylar emergency blankets are made up of Polyethylene terephthalate. This material is very compact and lightweight, and a great insulating material. One 2019 study by Hao Luo showed that "if the indoor heating set-point can be decreased by 4 °C, 35% of the total consumed energy can be saved”(Luo), proving that mylar is able to reflect up to 90% of body heat, and is thus what I used on the prototype.

In regards to human comfort, cotton fabric is known to be hypoallergenic and comfortable and it is also a very durable fabric, quite versatile and biodegradable. Research shows that cotton is more “susceptible than synthetic fibers (to bacterial growth) due to their porous/hydrophilic nature, retains water and oxygen along with nutrients, thereby offering optimal enrichment culture for rapid multiplication of microorganisms.” This shows that due to cotton's natural characteristics it is not an ideal fabric to use when attempting to shield from bacteria. Further, Ibrahim says that “direct contact with the human body supplies bacteria with warmth, humidity, and nutrients, i.e., provides a perfect environment and optimal conditions for bacterial growth” (Ibrahim 2008). While cotton's moisture absorption and relatively low antibacterial properties pose challenges, it can be treated to enhance its resistance against bacteria, thereby improving its overall protective qualities. Since my project did not focus on treating bacterial growth I have chosen to use polyester fabric instead of cotton. Polyester fabric is durable and requires less maintenance as it is easy to care for. “Synthetic fibers (such as)… polyester, … have some antimicrobial properties, which can further be enhanced through the treatment of antimicrobial compounds” (Gulati 2021). Polyester fibers exhibit reduced moisture retention compared to cotton, and they can be treated to enhance their antibacterial and antimicrobial properties. Given these inherent antimicrobial characteristics, polyester emerged as a more logical choice over cotton as one of the outer layer for the blanket. Linen is a natural fiber making it very eco-friendly, it is also a hypoallergenic fabric. This material is an ideal choice for temperature regulation, being able to keep the body warm in colder temperatures and very breathable for hotter temperatures. This material does absorb moisture but it dries quickly. Its moisture-wicking abilities can create an environment that is less favorable for bacterial growth compared to synthetic fibers.With this essential characteristic, I found it necessary to utilize it as the primary outer layer that is in direct contact with the human body. *Liquid Stitch* is a convenient and versatile fabric glue for quick projects–offering a strong bond on various fabrics. It provides precision application but may lack flexibility on stretchy materials. However, drying time and potential staining are factors to consider, making it ideal for temporary or no-sew solutions. For my project this was used as bonding between the materials.

<u>Experiment:</u>

This experiment aims to design a blanket for minimizing the effects of x-rays on the human body. To assess the shielding effectiveness of my materials, I utilized a hospital-grade x-ray machine, courtesy of Professor Thomas Riley and Professor Kathleen Taggart at Brookdale Community College Radiology Department. Initially, I conducted tests on individual materials, laying them out in single, double, and triple layers to gauge their radiation-blocking capabilities. X-ray testing revealed that three layers of Faraday fabric exhibited the highest potential for minimizing x-ray penetration. Subsequently, I employed a phantom—a model mimicking human tissue or anatomy—to further evaluate the shielding effectiveness. Placing three layers of Faraday fabric and Woven Stripe Linen on the phantom allowed for a direct assessment of shielding efficacy on a human body. The experiment yielded an approximate radiation output of 0.1 mSv, with precise radiation levels set at 60 kvp, 400 ma, and 25 ms. In an attempt to quantify radiation blocking, I tried using a personal Radiation Detector, but it was unsuccessful as the dosimeter requires a significant radiation dose, which the x-ray machine did not produce in sufficient quantities. This experiment demonstrates the promising potential of utilizing multiple layers of Faraday fabric to effectively minimize x-ray penetration and offers valuable insights into improving radiation shielding for human protection.

To actualize the objectives of this experiment, I crafted a prototype utilizing three layers of faraday fabric attached to mylar sheets, which were then enclosed within an outer-layer casing made of polyester faille and woven stripe linen. In my prototype, two square elements are joined together to capture the essence of a quilt-inspired blanket design. Additional pieces will be attached at the edges to avoid puncturing the Faraday fabric and Mylar. This prototype shows promise in minimizing x-ray penetration and offers insights into improved radiation shielding for human protection.

Results, conclusions, and future work:

In space, radiation levels fluctuate widely, exposing astronauts to 50-2000 mSv, akin to 150-6000 chest X-rays. My experiments only subjected materials to 0.03% of this dosage. Though visual inspection hinted at effective x-ray shielding, precise measurement was hindered by low radiation levels below the dosimeter's detection limit. Advancing this research requires access to higher radiation x-ray machines and more sensitive dosimeters. Access to classified NASA data would further refine and validate findings. These enhancements would deepen understanding and broaden potential applications of the materials' shielding capabilities.

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