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BEYOND THE LIMITS - ARBITRARILY LARGE ROTATING SPACE HABITATS THROUGH STRUCTURAL DECOUPLING

Abstract

Rotating space habitats have been a staple of space habitat design language since Tsiolkovsky's writings dating back to 1903. The notional conception of a rotating space habitat has a maximum theoretical size, which is due to the breaking length of the structural material. While this notional rotating space habitat concept has been universally assumed, it has a glaring design flaw: the structural mass contributes to the centrifugal weight. This flaw inherently limits the structural mass efficiency of the habitat and is solely responsible for the oft-cited maximum theoretical size. Although it might seem unavoidable, the limitations associated with this flaw are not intrinsic to the concept of rotating habitats and can be overcome. This study proposes a novel design solution: decouple the habitat and structure, enabling the habitat to function as a rotating inner ring encased within a static structural ring. By keeping the structural ring static, it need not resist the centrifugal force generated by its own mass, ensuring that the structural mass does not contribute to additional hoop stress. This research focuses on the application of superconducting magnetic levitation of the inner, rotating ring against the outer, static ring, thereby substantially diminishing the hoop stress on the outer ring. The core objective of this research is to validate the hypothesis that decoupling the rotating portion of the habitat from the support structure eliminates size constraints associated with rotating habitats and decreases the amount of structural material required. This validation is achieved through theoretical proofs as well as scale model demonstrations, which illustrate the fundamental principles. Consequently, this allows for the construction of extremely large habitats using rudimentary materials, challenging the predominant view that advanced materials are necessary for such structures. Such a habitat would maintain additional benefits, such as kinetic energy storage and straightforward docking/berthing. The results of this research have immediate implications for reducing the structural mass of prospective rotating space habitat designs and opens possibilities for using common materials in large-scale habitat construction. Given these outcomes, the findings not only pave the way for more efficient and sustainable space habitat construction but also signal a pivotal shift in the field. This research lays the groundwork for a comprehensive reevaluation of rotating habitat design, underscoring the need for further exploration in areas such as the development of orbital test beds for magnetic levitation, biological testing across different gravity levels, and comparative analyses of structural materials.