The Journals

John I Davies

Here we list recent interstellar-related papers in the Journal of the British Interplanetary Society (JBIS), published since the 1930s, and Acta Astronautica (ActaA), the commercial journal published by Elsevier, with the endorsement of the International Academy of Astronautics.

JBIS

Three issues of JBIS (online) have appeared since the report in our last issue, P41. Later issues are in print but not yet online.

Title (open publication)	**Author**	**Affiliation**
Abstract/Précis/Highlights		

JBIS VOLUME VOLUME 76 NO.2 FEBRUARY 2023 PAGES 70-76		
Exploring the Feasibility of a Power-Generating Pulsed Nuclear Magnetic Nozzle	Nathan M Schilling	University of Alabama in Huntsville

Crewed missions to Mars and robotic missions to the gas giant planets are challenging because of the current lengthy trip times (2 years to Mars, ~20+ years to the gas giants) with current propulsion technology. These trips endanger astronauts due to the harmful effects of radiation and microgravity and represent a significant fraction of a PI's (Principal Investigator's) lifespan for uncrewed gas giant missions. To make these trips safer and more reliable, trip times need to be reduced dramatically. Pulsed nuclear fusion propulsion systems promise to reduce these trip times down to 1-3 months for the Mars mission and 1-4 years for gas giant missions. However, widespread use of these systems is hampered by many technical factors, including efficient conversion of directed jet power for thrust and generation of input power for fusion reactor operation. To address both challenges, the present authors propose using the novel power-generating magnetic nozzle; this nozzle uses high-strength magnetic fields for thrust generation and low-strength fields for power generation. Most approaches in the literature consider the effect of either the high-strength fields or the low-strength fields but, for this work, the authors would like to show their combined effect. To address this, we use two computational tools in tandem from prior work: the Smoothed Particle Fluid with Maxwell equation solver (SPFMax) and a plasma flux compression generator code. The former will determine the effect of the high-strength fields and the latter will determine the effect of the low-strength fields. Combined, they show the effect on thrust, efficiency, and power generation. The present authors find that the inclusion of a power-generation system reduces nozzle efficiency by 7% and thrust by the same amount, however, this is a relatively small reduction. The authors also confirm prior work regarding non-dimensional scaling parameters of the power generation system. These results reduce the technical risk associated with these nozzles, hopefully allowing for their application in current concepts/programs, make interplanetary trips safer and more reliable, and allowing humanity to venture out and explore the solar system.

JBIS VOLUME 76 NO.3 March 2023 Interstellar Issue		
Mission Concept and Development of the First Interstellar CubeSat Powered by Solar Sailing Technology	Piotr Fil et al	Imperial College London

Project Svarog is a student-led initiative aiming to reach the heliopause using a solar sail. Orbital models have proven the feasibility of the mission given the mass-to-area ratio of about 9 grams per square meter of the sail for a satellite launched on a piggyback mission to Mars. Solar sailing increases the flexibility of missions to the outer Solar System, as unique planet alignment, which was crucial for gravity assists is no longer required. Long-term missions require a better understanding of thin membrane behaviour since buckling of sail material under solar radiation pressure might cause the spacecraft to tumble unpredictably. Reduced order model of membrane deflection is thus coupled with orbital simulation, resulting in the determination of the operation regime, for which the mission escapes the Solar System. Additionally, vacuum chamber experiments designed to investigate the effects of solar radiation pressure and heating on the transient and steady-state behaviour of the sail have been devised. The system is designed to be built as a 6U CubeSat, being one of the first missions to utilise small-scale platforms for deep space missions. Granted that the first mission is successful, the Svarog system could also serve as a low-cost testbed for new technologies and research opportunities in deep space.

A Re-appraisal of the Challenges Associated with Detecting Alien Signals and Technosignatures	Gary S Robertshaw	Royal Astronomical Society

The Rare Earth Hypothesis contends that Earth's unusual formation and distinct evolutionary pathways led to the unlikely emergence of Homo sapiens. This contention is developed further by combining the universal principles of the Newtonian n-body problem and Darwinism to argue that there is also an inherent randomness in the sequence, timing, duration and nature of evolutionary outcomes on alien worlds. This has two important implications. Firstly, where alien life might emerge, evolutionary pathways must differ considerably to those on Earth. Within this, intelligence is not the goal of evolution nor is it necessarily the best adaptation for a given niche; there is no systematic, inexorable progression towards higher intelligence and technology. Secondly, the chances of an advanced alien civilisation emerging from a separate, random evolutionary pathway with matching technology, and proximate signalling in deep time are vanishingly small. This re-appraisal of the challenges associated with detecting alien signals has the advantage of using two key universal principles without relying explicitly on anthropocentric assumptions.

Application of the HeliosX ICF Advanced Propulsion Mission Analysis Code to Perturbed Interstellar Design Models	Kelvin F Long	Interstellar Research Centre, Stellar Engines Ltd,

HeliosX is a system integrated programming design tool which has the purpose of calculating spacecraft mission profile and propulsion performance for inertial confinement fusion (ICF) driven designs. This code uses the vehicle configuration input and capsule assumptions and then calculates the likely mission profile for a given destination target. The key technology is the inclusion of the fusion propulsion system and an adequate modelling of its likely energy outputs. This paper discusses calculations for perturbed design concepts from a baseline model in both series and parallel thrust mode. These new concepts are collectively known as the advanced baseline models which are presented in preliminary form under the names Resolution, Endeavour and Pegasus. These are for missions to 4.3 ly in trip times of less than 100 years for flyby and rendezvous configurations carrying a 150 tons payload. The designs utilise an ICF capsule mass of 0.288 g filled with $D^{-3}He$ fuel detonated at a pulse frequency in the range 100-150 Hz. The calculations show that the propulsion systems are characterised by thrusts 0.3-2 MNkg-1, jet powers 1.2-9.2 TW and specific powers 2.9-5.1 MWkg-1 for interstellar missions at 0.045-0.049c. In addition to the preliminary mission performance calculations we also discuss the philosophy and methodology used in the design evolution.

Acta Astronautica

Title	Number+date	Author	Affiliation
The inferred abundance of interstellar objects of technological origin	Volume 208 (July 2023)	Carson Ezell, Abraham Loeb	Harvard University

Interstellar objects discovered crossing through the solar system can either be natural objects or technological artifacts from extraterrestrial civilizations. Evidence from our own civilization suggests that early-stage technological civilizations are already able to launch artificial objects beyond their star system, and early-state to late-stage technological civilizations in the Milky Way may have an interest in exploring potentially habitable regions throughout the galaxy. Based on our rate of detection for both natural and artificial populations of interstellar objects, we can estimate their respective local number densities and the total quantity of such objects bound by the Milky Way thin disk. We propose a model for calculating the quantity of such objects based on their observed velocity and number density. We consider the relevance of our model given several detections of interstellar objects over the past decade, and we discuss the implications of the estimated quantity of both natural and artificial objects for understanding their nature and origin.

Operational performance parameter range in ICF propulsion theory	Volume 210 (September 2023)	Kelvin F Long	Interstellar Research Centre, Stellar Engines Ltd

This paper explores the operational performance parameter range for inertial confinement fusion propulsion systems under the assumption of best case and worst case mission scenarios. This includes the spacecraft thrust, jet power and specific power. We show the derivation of the key driving equations and then simplify these with approximations for ease of domain space analysis. This includes a consideration of minimum and maximum values for jet efficiency, momentum weighting factor, nozzle divergence angle, fuel burn-up fraction, capsule mass and detonation pulse frequency. It is estimated that the range of parameter values may be of order 0.001 N–100 MN thrust, 1000 W–1,000 TW jet power, 0.01 W/kg–10 GW/kg specific power. Although this range includes values that are likely outside the realistic design space of applicability and to show this data from published designs is also examined. The analysis is considered for reaction isotopes of low mass hydrogen and helium nuclei only and does not take into account the possibility of propellant expellant augmentation, vehicle staging, design optimality or enhanced fuel reactions.

Project Lyra: Another possible trajectory to 1I/'Oumuamua	Volume 211 (October 2023)	Adam Hibberd	i4is

The first interstellar object to be discovered, 1I/'Oumuamua, exhibited various unusual properties as it was tracked on its passage through the inner solar system in 2017/2018. In terms of the potential scientific return, a spacecraft mission to intercept and study it in situ would be invaluable. As an extension to previous Project Lyra studies, this paper elaborates an alternative mission to 1I/'Oumuamua, this time also requiring a Jupiter Oberth Manoeuvre (JOM) to accelerate the spacecraft towards its destination. The difference is in the combination of planetary flybys exploited to get to Jupiter, which includes a Mars encounter before proceeding to Jupiter. The trajectory identified is inferior to previous finds in terms of higher deltaV requirement (15.6 km/s), longer flight duration (29 years) and less mission preparation time (launch 2026), however it benefits from a feature absent from previous JOM candidates, in that there is little or no deltaV enroute to Jupiter (ie a free ride) which means the spacecraft need not carry a liquid propellant stage. This is marginally offset by the higher deltaV needed at Jupiter, requiring either 2 or 3 staged solid rocket motors. As an example, a Falcon Heavy Expendable with a CASTOR 30B booster followed by a STAR 48B can deliver 102 kg to 1I/'Oumuamua by the year 2059. Other scenarios with shorter flight durations and higher payload masses are possible.

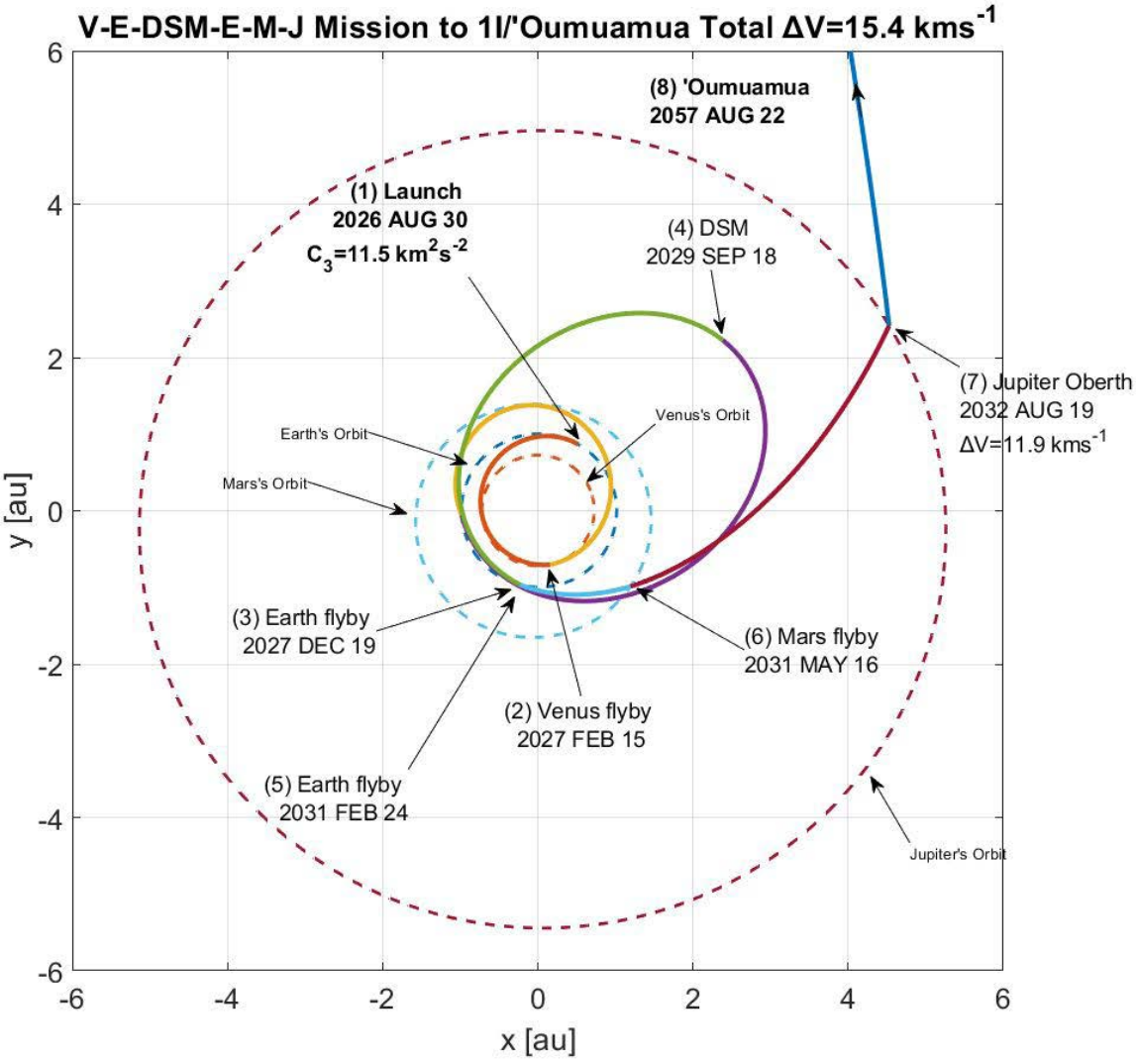

Illustration of trajectory from an earlier preprint version-
Project Lyra: There is Another Way Adam Hibberd. i4is.org/project-lyra-there-is-another-way/