Report from the Space Propulsion Conference 2024

Glasgow, 20-23 May 2024

Nadim Maraqten

Propulsion is the most prominent technical challenge to the interstellar endeavor and solutions as radical as faster than light (FTL) drives are proposed. However work is progressing on technologies ranging from those requiring radical physics to those at or close to feasibility and here Nadim Maraqten reports on work presented at the 9th Edition of the 3AF (Association Aéronautique et Astronautique de France) *International Conference On Space Propulsion*, 20-23 May 2024 in Glasgow, Scotland (www.3af-spacepropulsion.com). His own paper at the conference was *Reference Missions, Mission Level Needs and Evaluation of Candidate Technologies for High Power Electric Propulsion*. References are at the end of the article.

I am writing this brief report from the 9th edition of the Space Propulsion Conference (SPC), organized by 3AF and ESA, which took place in Glasgow in May 2024. The bi-annual conference serves as a platform for science and industry to discuss new trends and progress, particularly in chemical and electric propulsion. Please note that this is only a brief and subjective summary of the insights I gained and what I found particularly interesting for the interstellar community. While I aimed to highlight the contributions I found most significant, some details may have been overlooked, so I cannot guarantee full comprehensiveness. To travel to the outer solar system and beyond, with a significant payload mass, and within reasonable time, a very effective propulsion system is needed. Instead of speculating on the discovery of new physical phenomena that can be exploited as a new propulsion system, a more pragmatic approach might be given in using advanced versions of the heritage concepts based on mass variant Newtonian reaction (=propellant based). This was underscored by the keynote of Prof Tajmar "Overview of Breakthrough Propulsion Activities at TU Dresden - Exploring Possible EM-Gravity Interactions", who presented his research on the coupling of EM forces and gravity. The research concluded, "No anomalous forces or torques down to the nano-Newton or nano-Newton-Meter range were found providing new limits many orders of magnitude below previous assessments ruling out claims or theories and providing a basis for future research on the topic." More can be read in a recently published article in nature scientific reports [1]. An overview of the assessed coupling schemes is given in table 1.

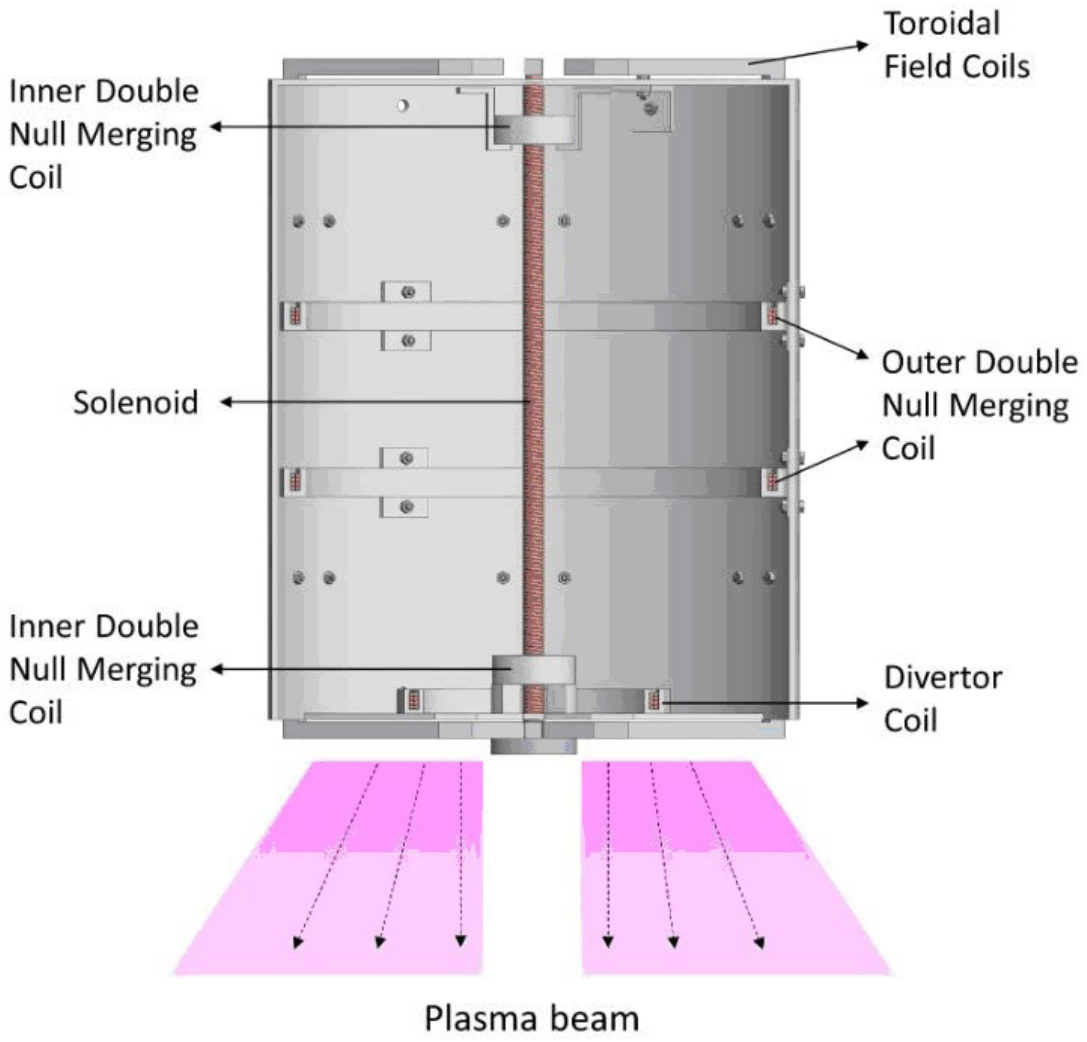
	Maxwell						Non-Maxwell
	Electric Field **E**	Magnetic Field **B**	**ExB**, EM-Wave	Charge **q**	Current **I**	Speed of Light **c** Vacuum $\varepsilon_0\mu_0$	Additional Scalar Field Magnetic Monopoles Born-Infeld EM, ...
Gravitational Field **g**	Ivanov Root Gravity*	Ivanov Root Gravity	EMDrive* Feigel Effect and Vacuum MHD		Superconducting*, Tunneling or Divergent Currents (Biefeld-Brown)*	Vacuum/Casimir Forces	Mbelek-Scalar Force*
Mass **m**	Assis-Weber Gravity Model and Electric Polarization*	Alzofon Nuclear Spin Polarization*		Inertial Mass from Stationary Charges* Saxl-Type, Kaluza-Klein*		ZPE Mass Models Curie-type Critical Temperature for Spacetime*	
*** Experimental results available in literature**							

Table 1. Coupling-schemes of gravity and electromagnetism including theory and experimental claims (crossed cell marks incompatibility between vector and scalar quantities, yellow areas are assessed in [1]). Credit: Tajmar et al

Thus, near-term interstellar precursors might rather be enabled by advanced versions of current propulsion systems (eg electric propulsion). These need to exhibit high Isps, to transfer convenient amounts of payload masses within reasonable time. High Isps might be achieved by exploiting new electromagnetic or electrostatic acceleration mechansims. One approach for this was presented by Dr Giulia Becatti, who presented an assessment of the "magnetic reconnection based thruster for high specific impulses" [2], on which she works on within a project funded by the EU via a Marie Skłodowska Curie Post Doctoral Fellowship. First estimates indicate the possibility to reach very high specific impulse at high level of thrust.

However, the main bottleneck of electric propulsion systems with high Isps is the specific mass of the power plant (α). With current α, very high Isps would lead to intolerably low accelerations (thus very long transfer times), because the needed power would result in a heavy electrical power system. To guide the optimization of the Isp, given the system constraints α, dv and the transfer time of a mission, R Gabrielli and G Herdrich have presented an extension on the non-dimensional rocket equation [3]. This can help with quantifying the possible Isp and α demands of interstellar missions with energy sources separate to the thruster.

Another and potentially ground-breaking approach for electric space propulsion could be given by using a joint energy source and acceleration system, such as a modified version of a Tokamak, as presented in [4] (see Fig 1). Potential benefits are high levels of power, in combination with a high Isp and thrust. However, the development is still in an early stage.



Tokamak-based electric thruster including main electrical components in development at Imperial College London [4].
Credit: Ali and Knoll. Figure 1

Concluding, given the impressions of the 2024 Space Propulsion Conference it appears to me that near-term interstellar missions are more likely to depend on advanced versions of existing propulsion systems, such as high-Isp electric thrusters. However, key challenges like power-to-mass ratios of the power plant remain. Promising concepts, like Tokamak-based propulsion, are still in their early stages but could offer significant breakthroughs in the future.

REFERENCES

[1] Tajmar, M, M Kößling, and O Neunzig - *In-depth experimental search for a coupling between gravity and electromagnetism with steady fields.* Scientific Reports 14.1 (2024): 19427. www.nature.com/articles/s41598-024-70286-w

[2] Becatti, G and Herdrich, G - *A magnetic reconnection based thruster for high specific impulses space missions*, 9th Space Propulsion Conference, Glasgow, Scotland (2024) www.researchgate.net/publication/381326376_A_MAGNETIC_RECONNECTION_BASED_THRUSTER_FOR_HIGH_SPECIFIC_IMPULSES_SPACE_MISSIONS

[3] Gabrielli, R and Herdrich, G - *Update on Rocket Equation Analyses for Separately Powered Space Propulsion*, 9th Space Propulsion Conference, Glasgow, Scotland (2024) www.researchgate.net/publication/381199565_UPDATE_ON_ROCKET_EQUATION_ANALYSES_FOR_SEPARATELY_POWERED_SPACE_PROPULSION

[4] Al-Ali, H and Knoll, A - *Power Supplies Design and Characterization for the Spherical Tokamak Thruster: A Novel High-Power Plasma Propulsion System*, 9th Space Propulsion Conference, Glasgow, Scotland (2024)

BELOW: Nadim at the SPC 2024 conference
Credit: Nadim Maraqten

ABOVE: Nadim presenting *Reference Missions, Mission Level Needs, and Evaluation of Candidate Technologies for High Power Electric Propulsion* www.researchgate.net/publication/381229294_Reference_Missions_Mission_Level_Needs_and_Evaluation_of_Candidate_Technologiesfor_High_Power_Electric_Propulsion/references
Credit: Nadim Maraqten

About the author
Nadim Maraqten is a postgraduate researcher working on applied-field magnetoplasmadynamic thrusters at the University of Stuttgart. He has been working with i4is since 2022, publishing papers with other i4is propulsion experts including Angelo Genovese and Dr Dan Fries - and contributing articles to Principium since 2022.
Nadim has a first degree in flight and spaceflight technology from the University of Stuttgart and is in the final phase of his MSc in Aerospace, Aeronautical and Astronautical/Space Engineering from the University of Stuttgart and Technical University of Delft.