Outer Space Driftwork

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three images

1. One infographic of the solar system showing motion in interplanetary space – including objects of all sizes from dust up to planets – still looking for a good one.
2. One image of a solar sail spacecraft
3. Another spacecraft image – maybe a multi-generational starship

Introduction

'Space is empty – a lifeless void, a vacuum. Moving in space is thus completely different from moving in Earthly environments – land, ocean, water – because in space there is nothing in the environment that you can push against with limbs, wheels or propellers. In space the only way to move is by hurling mass backwards, thereby propelling you forward – hence rockets – right?'

'And because space is empty it can be used as we please: we are free to exploit, settle or even terraform entire worlds – right?'

In this chapter we say 'wrong' to both these questions, in ways that connect them together. We use what first seems a purely technical matter – how things move in outer space – to sketch a different view of not just *how*, but *why*, we might voyage in space. Outer space, we suggest, is not just empty space to be traversed to reach predestined places, but a *place in itself*, an environment with its own (albeit curious and distinctive) properties, and one that can and should evoke more expansive ways of thinking about travelling and purpose.

But even this is maybe not quite enough of a change of perspective. We want to suggest that we view space not just as a collection of static spatial coordinates to move between and across, but as itself a set of motions and movements, a pattern of paths of different shapes that weave within, between and around the bounded objects that are studied by astronomy. This distinctive approach to outer space mobility, we think, can help us glimpse other possibilities and purposes of space travel.

We are both social scientists, so our day job is contributing to an understanding of human social life in all its complexity. But we approach this task in a distinctive way, because we see human society as part of the longer, much-more-than-human story of the evolution of form, order and complex matter on our planet. So, we draw our ideas not only from the social sciences and humanities, but also from biology, ecology, physics, the Earth and planetary sciences – along with speculative thought and fiction.

In our own version of 'planetary social thought' (Clark and Szerszynski 2021), we try to keep in mind that if we are to situate human social life in a planetary context, we need to remember that the Earth is not the only planet. Planets are *multiple, different*, and in many senses of those words: numerically (there are many planets), qualitatively (each develops its own unique identity), internally (each planet is divided, restless, active) and temporally (planets change over time, sometimes into a radically different world). And we like to think that human otherness and creativity – the seemingly endless exploration of different ways of being human – are part of the story of multiplicity and variability that characterises our planet. Which prompts the question: what might happen to that human diversity or difference if we leave Earth – and encounter other astronomical bodies and all the spaces between them?

With this in mind, our chapter addresses three questions: How might we move in space other than by using rockets? What can we learn about voyaging in space from the diverse ways that things move on Earth? And, building on the answers to these two questions, how might we go from considering *how* we travel in outer space to reimagining *why* we would be doing it?

Space without rockets

Let's start with the most familiar mode of space travel: rockets. Rockets work by carrying and then expelling on-board 'reaction mass', exploiting Newton's second law of action and reaction: if in space you push a mass away from you, then that force also acts on you, pushing you in the opposite direction. If you propel even a small mass away at very high speed, such as through burning fuel or nuclear explosion, then the reaction on you and hence acceleration is proportionally higher.

But other potential space transportation methods are under consideration in space technology and science fiction. Some focus on how to get from the Earth's surface into space without rockets – for example by using space elevators or balloons (see e.g. La Frenais and Chardronnet 2022); others are focused on how to move in space itself – such as by solar and magnetic sails, or a more systematic exploitation of gravitational slingshots.

But before we consider space craft, both existing and imagined, perhaps we should ask whether there are already things moving in interplanetary space in interesting ways. For interplanetary space may in one sense be virtually empty (with only about five tiny dust particles per cm^3 in the vicinity of the Earth's orbit) in other senses it is definitely not mere 'empty space'.

For a start, interplanetary space is full of *fields*, that make things in space move the way that they do. The scientific concept of the 'field' was developed initially as a mere mathematical abstraction to conveniently summarise the shifting balance of forces and gradients across a region of space. But in the nineteenth century, physicists started recognising that some fields at least (such as electromagnetism and gravity) were real, physical things – making it possible to think of something being 'physical' even when not material or locatable at a particular point in space, and of 'energy' as something that can exist even where there is no matter (McMullin 2002).

Gravitational and electro-magnetic fields play an important role in the motion occurring in interplanetary space. In our solar system, the sun is central to both kinds of field, as are the large outer planets, especially Jupiter. But things moving in space are also negotiating a thin but not negligible 'interplanetary medium', so that a body's movement in space can also be shaped by its interaction with an interplanetary 'flow field' – a spatially ordered pattern of varying density and velocity of the medium.

All of these fields vary greatly in intensity with distance from the sun or planet that is generating them. But also how an object in space *responds* to the fields around it depends crucially on its size and mass.

The motions of the ***largest*** and ***densest*** bodies such as planets, asteroids and comets are dominated by the gravitational field, which is whay they take the familiar form of 'free-fall' orbits – elliptical or circular in the case of returning objects like planets, parabolic or hyperbolic in the case of ones on a one-time escape trajectory around the central gravitational body. But even here there are more complex dynamics, such as Lagrange points created by the three-body gravitational relationship between a moving body and two other large bodies such as a planet and its sun – for example the stable L4 and L5 Lagrange points that always keep sixty degrees ahead and behind Jupiter, in which its populations of attendant 'Greek' and 'Trojan' asteroids have gathered. So even the emptiest space can contain places with different physical properties – albeit places that are always in relation to the moving bodies around them and thus themselves in constant motion.

At the other end of the size/mass spectrum, the movements of the ***smallest*** solar system bodies such as dust particles are much more responsive to the flow field of the interstellar medium. As well as the constant flow of photons from the sun in the form of electromagnetic radiation, the sun emits a solar wind of charged subatomic particles at speeds of up to 750 kms^{-1}, mainly in the plane of its equator. Dust, depending on its size and mass, might be pushed out of the solar system by sunlight or solar wind pressure – or conversely it might have its free-fall orbit perturbed, causing it to fall into the sun.

So what does all this motion mean for human space travel, both existing and imagined? Crucial to note here is that the size of the typical spacecraft is *way smaller* than a major astronomical body, but *way larger* than a dust particle. This, plus the human ability to consciously design and pilot a craft, makes it possible to creatively explore the possibilities open to entities of this intermediate scale, and thus to exploit the different forces and modes of movement in space.

Travel to the Moon and other planets already uses Lagrange points and gravity slings – we can see this as interacting with the shape of the gravity field as it is curved around the sun and its planets. But there are also experiments underway for propelling spacecraft with solar sails that rely on radiation pressure from electromagnetic energy, especially the light emanating from the sun. This involves unfurling a vast but thin sail structure, to create a low-mass but high-surface area shape, as used for example by the Japanese solar sail-powered spacecraft IKAROS launched in 2010. Acceleration forces are low but can be sustained for long periods without need of onboard reaction mass and fuel, resulting over time in huge velocities. And solar sails create more than the possibility of being pushed and accelerated away from the sun: solar sailors could use the phenomenon of 'optical lift' to generate a force and thus acceleration at an angle to the incoming light direction, just like sailors 'tack' in relation to the wind. A spacecraft with a *magnetic* sail can tack in similar way, in this case deflecting the flow of magnetically charged particles in the surrounding medium, and thereby gaining a small but 'free' acceleration in the opposite direction.

Looking at how both existing astronomical entities and human technological objects move in space can help expand our imagination. But turning our attention 'homeward' and taking a fresh look at how things move in and on Earth can also help us to think more creatively about moving in interplanetary space.

Learning from the Earth

If interplanetary space can be seen as an entangled web of lines, and of various kinds of motion, then this is also true of the Earth itself – and other planets (Ingold 2015; Nail 2021). Dynamic, restless planets like the Earth display a panoply of movements ranging in scale from the largest such as continental drift, jet streams and oceanic gyres, through migrating megafauna and human powered transport, past grazing animals and bacteria following chemical gradients, down to the scale of the Brownian random microscopic motion of molecules in the oceans and atmosphere (Haff 2010).

But in the dense interwoven context of planetary existence, these movements can rarely be isolated as wholly separate phenomena, and instead arrange themselves into diverse choreographies of motion of single and multiple entities or regions of undifferentiated matter: advection and diffusion; mixing and sorting; dispersing and gathering; singular and repeated movements; shuttling and cycling; and so on. Some of these intraplanetary movements are drawn to '*tune*' with each other – often involving the exchange of energy and/or matter from one moving thing to another. Sometimes they organise themselves into different timescales, thereby creating enabling and steering relationships between each other – between for example the slow processes of a river channel formation and the fast flow of water down the channel (Szerszynski 2022). At other times, different movements may *clash*, as for example when geological upheavals impede animal migrations or when human fossil-fuelled mobility contributes to the instability of flows of air and water.

But for all this diversity, there is one general message we can take: that entities move by drawing in different ways on the powers and properties of the environment around them – and here there are useful analogies between *intraplanetary* and *interplanetary* motion. Let us take two cases.

- Rockets can be seen as based on a certain reading of the ***locomotion*** of the animal body (Szerszynski 2016): moving in a chosen direction by actively pushing against the environment (though in the void the rocket has to in a sense push against *itself* – the share of its onboard reaction mass that it expels). Because it is goal-directed and involves expending energy and force, we can characterise such motion as a kind of 'work'.

- By contrast, outer-space objects moving in freefall trajectories, or moving in response to the interstellar medium, are more analogous to a very different class of Earthly moving things, such as sediment particles and seeds: they are passive, having their path determined solely by the ambient gravitational forces of the field around them – they are engaged in 'drift'.

But in the Earth, as in space, there is a huge space of possibility between these two options, grounded in a wider more-than-human range of paradigms of motion. We can call these in-between forms of motion '***driftwork'*** because of the way they combine 'drift' – motion powered by and in tune with the gradients of surrounding fields – with the more energy-expending, goal-directed 'work' (Szerszynski 2019). Gravity slingshots, for example, evoke the dynamic soaring of birds, who capture kinetic energy from the difference in velocity of different layers of the air, while solar sails recall the curious *Velella velella* jellyfish with its sail that allows it to drift at an angle to the wind.

Why things move

So far we have focused on the different technical options of moving in outer space – the *how*. But what about the *why*? Here we mean not just the specific goal of a particular space voyage, but the whole way of thinking about the purpose and function of space travel – the movement of clusters of complex matter across outer space, perhaps connecting up discrete astronomical bodies.

A common way of thinking about the relationship between 'how' and 'why' makes a strong distinction between them – between 'is' and 'ought'. On the one hand, this way of thinking goes, there are matters of fact, about the way things *are*, and how things work; on the other hand there are questions about right and wrong, about how things *ought to be*.

There are important and valuable impulses in that distinction. For example, the way that society *is* currently arranged is not necessarily a good guide to how we *ought* to live and treat each other. In modern societies, that idea of a sharp division between 'is' and 'ought' seems firmly held. The rise of liberal democracy institutionalises the idea that how society happens to be arranged is not a reliable guide to how it ought to be, while modern science is based on the idea that the nature of physical reality is independent of how we think it ought to be. And modern technology – for example tools, machines, energy distribution systems or algorithms – are generally understood as neutral devices, means to ends, without ethical implications in themselves.

But this is/ought distinction can be overstated. Particularly under the conditions we find on planets – energetically open thus dynamic and restless, but materially (more or less) closed, so creating a dense meshing of interactions – how things move becomes entangled with function and purpose. This is true of living things, subject to the mill of evolutionary pressures and opportunities – but also true of non-living planetary processes such as hydrological cycles and sediment flow.

Animal powered locomotion is profoundly shaped by the goal of finding food – or conversely of avoiding becoming food oneself for another animal (Butterfield 2011). As we noted earlier, the rocket is in some ways modelled on animal locomotion. But – as evidenced by the entanglement of space rockets and missile technology – much of the current prioritization in space travel of point-to-point travel and bounded missions with single objectives is also shaped by military practices of attempting to get projectiles to hit well-defined targets, itself closely related to practices of claiming, defending and extending territory.

But taking a deep time, planetary perspective reveals that Earth history has been dominated not by projectile or locomotive movement. It was *drift* that constructed the world that animals came to inhabit – through the sinking and settling of chemical elements into compartments, the interaction of landmasses with the cycling of rock deep in the mantle layer, the settling of sediment that became the sedimentary rocks, the pushing-together of tectonic plates and the driving-up of mountains, and the concentrating of minerals into ores and deposits by subterranean hydrological flows. In today's world, plants and fungi still use drift to disseminate and spread.

But even animals use drift, harnessing its distinctive properties to their own needs, purposes and goals in diverse forms of driftwork. The gliding birds mentioned above can cover vast distances without expending hardly any of their own onboard energy stores. And humans and other animals engage in episodes of 'drifting' across the landscape that have the effect of increasing their chances of encountering unexpected opportunities, such as for feeding or reproducing (Clark and Szerszynski 2021: 132-4).

How might we transfer such insights to space travel? If we approach the non-combustive forms of propulsion being explored for human space travel as forms of outer-space-driftwork, analogous to the kinds of driftwork that Earthly mobile entities engage in, can we use it to open up new ideas or imaginaries for future space travel?

Becoming otherwise

Outer space is a challenging place for humans and other Earth-born creatures; the distances tend to be immense, and much work is necessary in order to merely stay alive. But if we believe that the purpose of leaving Earth is not just to *get somewhere else* but to *become something else*, then we need to be open to trajectories, encounters and sojourns that are not entirely predictable.

As social scientists, we are only too aware of the limiting effects of voyaging across the Earth's surface without a willingness to be surprised, influenced and altered by those we meet along the way. Historically, such intransigence or hostility in the face of difference has often been deeply destructive. But many peoples have had traditions of hospitality, of welcoming strangers, which can make terrestrial driftwork less risky than it would otherwise be. So too are we attentive to the way that nonhuman living things have exceedingly long histories of encountering each other, exchanging genetic or other material, and even merging into novel beings.

Both critical social science and science fiction have warned against human extra-terrestrial ventures that simply impose pre-existing logics and desires onto other worlds and thereby treat outer space as territory to be claimed and exploited. We are suggesting that considering *how* we travel in outer space is closely implicated with the matter of *why* we go there. Maybe leaving behind the Earth is also an opportunity to leave behind the rocket, and also the very metaphors that we use to understand what space travel is.

Timothy Morton (2022) has suggested a similar move in respect of the language we use to refer to space vehicles, suggesting that we abandon the term 'space***ship***', because of its connotation of a large vehicle, with well-defined crew roles within it, and part of a larger system with clear rules, goals and command structures. Instead, he favours the term space***craft***, using examples from science fiction of spacecraft by contrast are small and 'fuzzy' in their ownership, often won in a bet, stolen or found; with fluid structures of command within them – and often travelling with changing goals or undefined purposes.

In sympathy with this move, we are suggesting that, learning from the complex entanglement of motion and purpose amongst Earthly entities, and connecting it to the diverse ways that things can move in interplanetary space, can help us think in far more imaginative ways of thinking about an off-Earth future, beyond paradigms of 'frontier', 'security', 'colonisation' or 'exploitation'. Attuning to space as a milieu of mobilities and forces invites us to move like sailors: travelling in ways deeply attuned with space as a milieu with its own properties; undertaking journeys with fluid goals and purposes, that coalesce and transform on the way; moving as part of a choreography of diverse interacting more-than-human motions of mixing and sorting, gathering and dispersing. Only then will we start to glimpse the full opportunities posed by Off-Earth movement for reimagining human futures.

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