Soliton solutions to the dynamics of space filling curves

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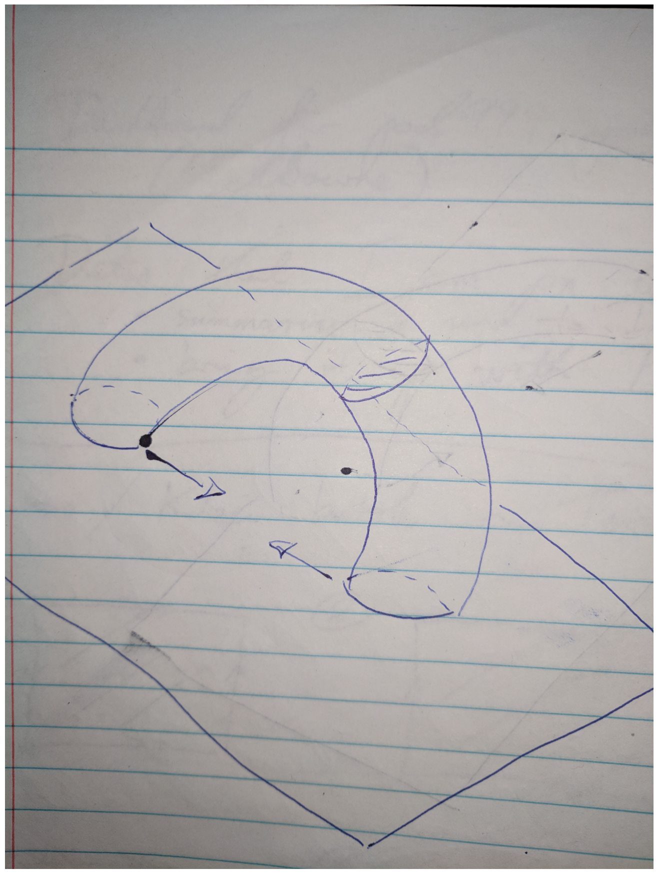
Abstract

I sketch roughly how an Alcubierre drive could work, by examining exotic geometries consisting of soliton solutions to the dynamics of space filling curves. I also briefly consider how remote sensing might work for obstacle avoidance concerning a craft travelling through space via a 'wormhole wave'. Finally I look into how one might adopt remote sensing ideas to build intrasolar wormhole networks, as well as extrasolar jump gates.

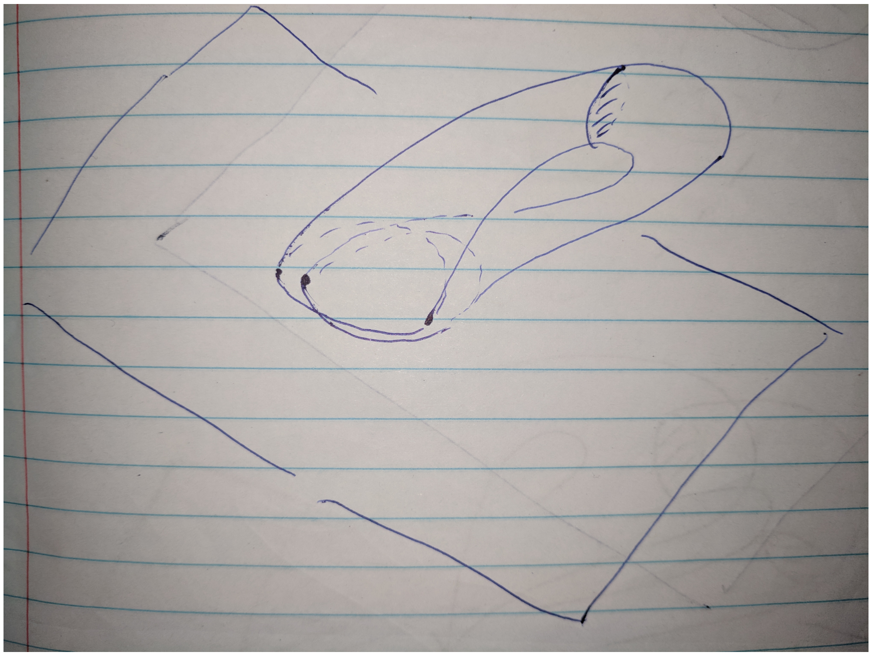
1 Forward

1.1 Summary

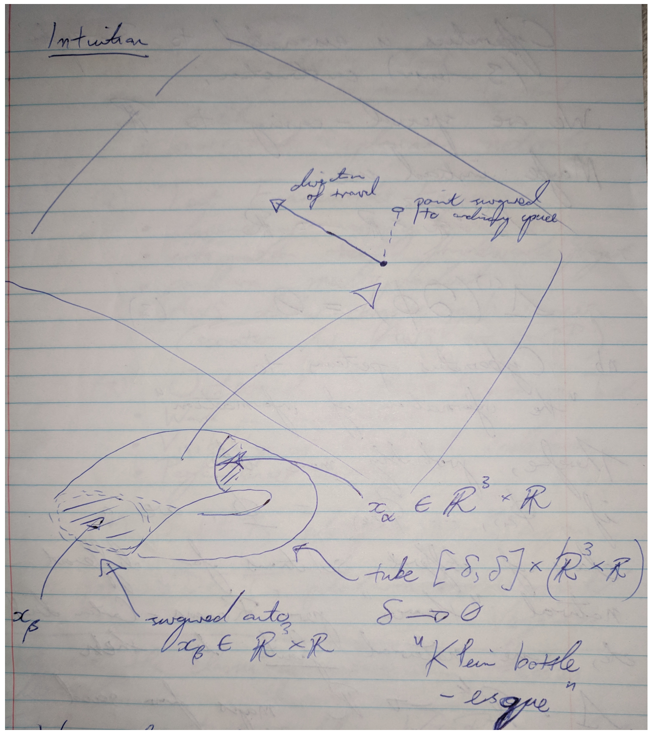
Heuristically, the general idea of the argument is as follows: consider the classical notion of a wormhole connecting two timelike volumes of a Lorentzian manifold, A and B. This can be viewed naively as a tube diffeomorphic to the interval product a compact subset of our manifold M, ie I x M, joining A to B surgered at both ends of the tube. In other words, we can sort of 'fold over' M so that we have a tube connecting A and B, which may be at some considerable distance from each other. This is the classical view of a wormhole.



Now, consider letting A approach B, so that the distance becomes smaller and smaller. Suppose further that the distance becomes so small that A intersect B is non zero. Suppose even further that the distance between A and B is so small that A and B are the same almost everywhere except on a set of measure zero, ***but*** are still joined by a tube diffeomorphic to I x M. Then let the length of the tube become shorter and shorter, so that it has length 2δ, and take the limit $\delta \to 0$, so that these sets are essentially connected by a wormhole bridge of infinitesimal length.



This may seem like a silly idea, but if say we have an object that sits in between A and B and external to real space, by causing it to sit within the infinitesimal tube connecting A and B, we can then ask the question as to whether it would be possible for this lift out of real space to be able to be propagated at the ends surgered onto real space at A and B, through the solution of some sensible analogue of a soliton solution to an integrable equation, and whether the speed limit of this solution would not be subject to the same cap as the solutions to propagation of the same object were it in ordinary space.



In order to construct the machinery in order to consider this in a mathematical sense, we need a few objects.

Suppose (M, σ) is a standard Lorentzian manifold. There are actions on M by $Aut(M)$, the space of diffeomorphisms $M \to M$ that act locally on M as 'automorphisms'. There are local coordinates for $Aut(M)$ realised as f_{ij} in function space, and these can be characterised by an 8-tensor λ, which can be built out of three exotic extensions of M by the operators $\wedge$, $\star$, and $\circ$ that act on statistical distributions corresponding to pre-geometric analogues of Lorentzian manifolds per [Go1], [Go2].

There is a further lift of $Aut(M)$, where $Aut^{(2)}(M)$ acts on $Aut(M)$ on the left and the right. Similarly, there are operators $\wedge^{(2)}, \wedge, \star, \circ, \circ^{(2)}$ that act on 3-tuples of statistical distributions, which form a natural 2^{256} dimensional tensor corresponding to the first jet bundle for M.

This is, however, a bit of a simplification, due to cybernetic considerations. We also need to consider 3-tensors as well.

For intuition, the action of $AutAut(M)$ on the left of $Aut(M)$ describes a gluing of M to the infinitesimal tube diffeomorphic to $Aut(M)$ on one end, and the action of $AutAut(M)$ on the right of $Aut(M)$ describes a gluing of $Aut(M)$ to M on the other. These actions are natural constructs relating to matrix multiplication by the first jet bundle in local coordinates either on the left or on the right.

Soliton solutions are realised by solving an integrable PDE created by augmenting this construction with the 3-tensor associated to the first order cybernetic extension of this exotic geometry.

2 Solitons in exotic geometries

2.1 Some Background

We consider for cybernetics a 3-tensor σ defined over a manifold M, such that for vectors u, v, w, $\sigma(u, v, w) = \langle u, v, w\rangle_p$ is smooth over $p \in M$, and trilinear in u, v, w.

Define $\Gamma^{\alpha}_{ijk} := \langle \partial_\alpha E_i, E_j, E_k\rangle$, where $\{E_i\}$ form a basis for the tangent bundle of M.

Define $Inv(\sigma) := \sigma_{ijk}\sigma_{lmn}\Gamma_{ilab}\Gamma_{jmbc}\Gamma_{knca}$ as the information invariant associated to σ, where

$$I := \int_M f|\partial lnf|^3_\sigma dp := \int_M Inv(\sigma(p))dp$$

is the information. Note that $Inv(\sigma) = 0$ when I is critical, which is a third order PDE.

For the dynamics of space filling curves, we consider the following construction:

Per [Go2], we are interested in 3-tuples of signal functions, f, g, and h, and operators on same $\star$, $\wedge$, $\circ$. We are also interested in the multiplicative tetration ($\wedge^{(2)}$) and compositional tetration ($\circ^{(2)}$) operators.

Here for instance we define say $\star\wedge(f; g; h) := f^g h$, where prototypically f, g, and h could be Dirac delta functions of the form $f = \delta(\sigma(m) - a), g = \delta(\tau(m) - b), h = \delta(\gamma(m) - c)$ for different metrics σ, τ, and γ over a manifold M.

Here also by tetration I mean the operator $\wedge^{(2)}$ such that

$$\wedge^{(2)}(f; g) := f \wedge \cdots \wedge f$$

where g copies of the exponentiation operator $\wedge$ are taken. Note that we are primarily interested in the case where $g \in [0, 1]$, ie, where g is decidedly not a natural number, so evidently the appropriate generalisation of the above is understood to be being used (in an analogous manner to the relationship between the Gamma function $\Gamma(n+1)$ and the factorial $n!$).

Similarly, by compositional tetration, I mean the operator $\circ^{(2)}$ such that

$$\circ^{(2)}(f; g) := f \circ \cdots \circ f$$

where again g copies of the composition operator $\circ$ are taken.

Consider now if a base geometry, ie a Dirac Delta, takes an eight tensor Λ as input; then there are 20 possible ways to build structures involving 3 signal functions using the 5 duple operators, and 3 additional ways to build structures involving 2 signal functions (a signal function is a distribution of the form $f = \delta(\Lambda(m) - a)$), using the first order duple operators $\circ, \star$ and $\wedge$, and one geometry for the base (a singleton signal function).

This leads to dimension 24×8, or 192. 192 can be lifted to 256 dimensions if we realise that we have natural operators $TM \to_\alpha TM$ such that the natural degrees of freedom are the $\wedge$, $\star$ and $\circ$ operators, so that there are an additional 4^3 or 64 dimensions, making 256 in total.

But note that we did not take into account double composition in $Aut(JM)$, where JM is the first Jet bundle, ie $JM \to_\phi JM \to_\psi JM$. Then we can act either on the "left" or the "right" of $AutAut(JM)$. But this is more of a consideration for the theory concerning soliton solutions of space filling curves.

Therefore we are interested in finding a tensor invariant for the dynamics of space filling curves of order 2^8.

We would like to write this in double index notation in which Christoffel symbols (structural coefficients) can be described, and from this basis an information built.

Note that for a 256-tensor (4^4 tensor) we can adopt the notation $\Lambda_{B_{ijkl}}$ where i, j, k, l can take values from 1 to 4, and we consider all permutations of the B_{ijkl} to characterise Λ, so ie. $B_{1111}B_{1112}B_{1113} \cdots B_{1121}B_{1122} \cdots B_{4444}$. Then in this convention, each B_{ijkl} is an indice of Λ, so we are doubly indexing.

Note equivalently we can adopt the notation $\Lambda_{K_{ij}L_{kl}}(m, n)$ where K, L are matrices, and define this as a tensor over the topological product of M with another space N.

For Christoffel symbols, we consider just as $\Lambda = \Lambda_{\underline{\underline{AB}}}$, then

$$\Gamma^{\underline{\underline{K}}}_{\underline{\underline{IJ}}}(m, n) := \langle \nabla_{\underline{\underline{K}}} X_I, X_J \rangle_{\Lambda(m,n)}$$

where the $\{X_I(m,n)\}$ are a basis for a local chart of the Jet Bundle associated to $M \times N$, $(J(M \times N))$, and so therefore are 4 by 4 matrices and $\nabla_W V$ is defined as:

$$\nabla_W V := \Pi_i \nabla_{w_i} V$$

Note due to dimension criticality (see [Go1]) this will be generically dimension 4.

Then we have a natural geometric invariant

$$R(\Lambda)(m,n) = -\Lambda_{IJ}\Gamma^C_{IB}\Gamma^B_{JC}$$

If we consider the Cramer-Rao inequality for the information associated to the first order dynamics of space-filling curves:

$$I(\Lambda) := \int_{M,N}\int_A f(m,n,a)|\partial ln f(m,n,a)|^2 dmda$$

where $f(m,a) = \delta(\Lambda(m,n) - a)$, then I claim this is equivalent to

$$I(\Lambda) = \int_{M,N} R_\Lambda(m,n)dmdn$$

For the information to be critical then, $R_\Lambda = 0$, and this is an 8th order PDE over $M \times N$.

So we have described information theories of space filling curves, and information theories for cybernetics. To put these together, observe that there are four choices of gluing of N to M, so we have 4 different information theories for space filling curves. These can roughly be constructed by choice of the dual metric in M and or N, creating four permutations, which will influence the associated geometric invariants to said theory.

In Riemannian geometry, the metric dual is constructed via

$$\sigma^\perp_{ij} \text{ st } \langle \nabla_i X_j, X_k\rangle_\sigma = \langle X_j, \nabla_i X_k\rangle_{\sigma^\perp}$$

Similarly, we have four different ways the connection can operate:

$$\begin{aligned}\Gamma^{A}_{BC} &= \langle \nabla_A B, C\rangle_{\Lambda} \\ &= \langle B, \nabla_A C\rangle_{\Lambda^{\perp, Id}} \\ &= \langle \nabla_{A^T} B, C\rangle_{\Lambda^{Id,\perp}} \\ &= \langle B, \nabla_{A^T} C\rangle_{\Lambda^{\perp,\perp}}\end{aligned}$$

These four permutations give rise to four different information theories for space filling curves, corresponding to the action of $Z_2 \times Z_2$ on Λ. The information invariants associated to these theories can be represented as coordinates:

$$(R_{\Lambda^{(0,0)}}, R_{\Lambda^{(0,1)}}, R_{\Lambda^{(1,0)}}, R_{\Lambda^{(1,1)}})$$

and give arise generically to a Lorentzian geometry M defined over the space of these theories.

Applying the cybernetic considerations at the start of this section, we can build a meta-functional over this space, or a theory of theories - an information of information; hence my original coining of the phrase cybernetics.

Then we naturally have a geometric invariant

$$Inv(R_{\Lambda})$$

where by abuse of notation I am now referring to R_{Λ} as

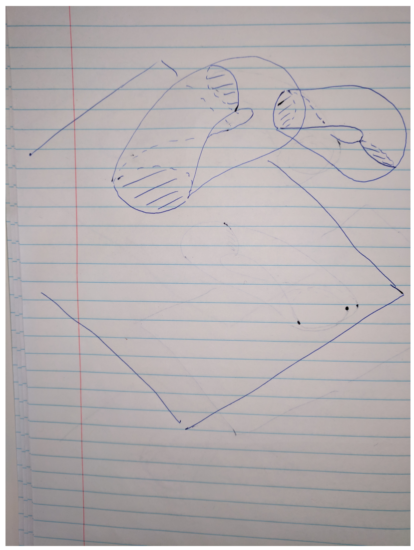
$$R_{\Lambda} := (R_{\Lambda^{(0,0)}}, R_{\Lambda^{(0,1)}}, R_{\Lambda^{(1,0)}}, R_{\Lambda^{(1,1)}})$$

Then soliton solutions of space filling curves that concern us take the form $Inv(R_{\Lambda}(m,n)) = 0$, which is an 11th order PDE. Further justification for this conclusion will be given in a later section, on the connection between solitons and cybernetics.

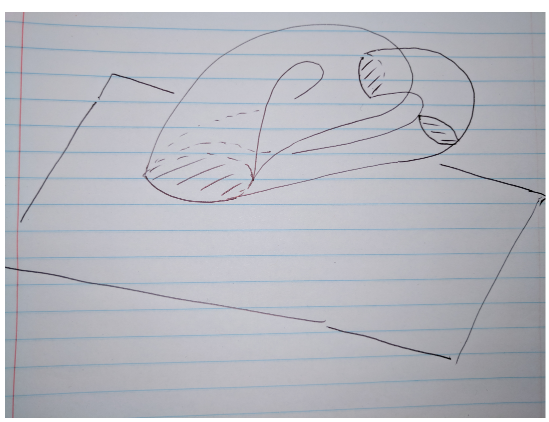
2.2 Ultradrive and higher order considerations

These considerations can of course be generalised to the case where we consider second order cybernetics, or the information of information of information. In this case, we are not just considering theories as points in space, but theories of theories as coordinates.

An example of a higher order gluing:



A second example of a higher order gluing:



With such considerations, we are interested in roughly $\Lambda = \Lambda_{B_{IJKL}}$, where I, J, K, L are 2 by 2 matrices which themselves are indexed, with

$B_{1_{1111}1_{1111}1_{1111}1_{1111}} B_{1_{1111}1_{1111}1_{1111}2_{1111}} B_{1_{1111}1_{1111}1_{1111}3_{1111}} \cdots$
$B_{1_{1211}1_{1211}1_{1211}1_{1211}} B_{1_{1211}1_{1211}1_{1211}2_{1211}} B_{1_{1211}1_{1211}1_{1211}3_{1211}} \cdots$
$B_{1_{1111}1_{1111}2_{1111}1_{1111}} B_{1_{1111}1_{1111}2_{1111}2_{1111}} \cdots B_{4_{4444}4_{4444}4_{4444}4_{4444}}$

a representation of the indices of Λ.

Then there are roughly $4 \times 4 \times 4 \times 4 \times 4 \times 4 \times 4 \times 4$ degrees of freedom here, or 2^{16}.

Equivalently, we can represent $\Lambda = \Lambda_{\alpha\beta}$ where $\alpha = \alpha_{\underline{\underline{\underline{AB}}}}$, $\beta = \beta_{\underline{\underline{\underline{CD}}}}$, as a triply indexed tensor.

Furthermore, there are an additional 8 degrees of freedom (another eight indices) which encode the information relating to a 'jump' from the deepest level of the tree to the top level, i.e. there is a group action of $Z_2 \times Z_2 \times Z_2 \times Z_2$ on this structure, which establishes an information connection 'on' or 'off' for the x_i, $i = 0, 1, 2, 3$ in ultraspace P, and ordinary space M. The intuition here is that this comes down to a choice of the gluing above, whether it is direct or indirect.

Consequently, if we define this set of group actions as G, then $\Lambda = \Lambda^{(G)}_{\alpha\beta}$, which is a 2^{19} tensor.

And, proceeding by analogy:

$$\Gamma^{\gamma,(G)}_{\alpha\beta}(m, n, p) := \langle \nabla_\gamma X_\alpha, X_\beta \rangle_{\Lambda^{(G)}(m,n,p)}$$

where X_α is an element of the second jet bundle over $M \times N \times P$, ie $J^{(2)}(M \times N \times P)$. The order of these symbols should be an eighth order derivative.

Then continuing to push the analogy, we have a natural geometric invariant

$$R(\Lambda^{(G)})(m, n) = -\Lambda^{(G)}_{\alpha\beta} \Gamma^{\delta}_{\alpha\gamma} \Gamma^{\gamma}_{\beta\delta}$$

These invariants form an 8-vector over G.

Note however that a more natural geometric invariant comes via resolution over all elements of G. This leads us to the formulation of a cybernetic invariant over G:

$$\hat{R}(\Lambda) = Inv^{(1)} \circ R(\Lambda^{(G)})$$

where $Inv^{(1)}$ is the natural cybernetic invariant from before, but defined over $N \times P$, representing how to glue ultraspace to hyperspace.

If the above is 0, with information criticality, then we must needs solve a 19th order PDE, as we have 16 from the information invariants, and 3 from the composition with 1st order cybernetics.

But to build a full theory of ultradrive requires that we consider theories of theories, or 2nd order cybernetics, as there are multiple choices of gluings of M to N, N to P, and P to M.

Ultimately we must needs find an invariant $Inv^{(2)}$ such that over the four cybernetic theories $Inv^{(1)} \circ R(\Lambda^{(G)}(H))$, where $H = Z_2 \times Z_2$ represents the choices as to how to glue N to M (hyperspace to ordinary space). By transitivity this implies by implication we are also considering how to glue ultraspace to ordinary space if need be.

Note that we need to consider too the 1-categorical lift of the first meta-cybernetic theory, so instead now of $Inv^{(1)}$ being 3rd order it is 10th. This is associated with a shift of concern for said cybernetic construction away from ordinary space M to the function space of $M \times N$, and from a 3-tensor to a 3^5 tensor.

More prosaically, if we adopt the notation that for function space for 2-tensor constructions, if E_{ij} forms a basis for the function space, then generically we have four tuples of these being considered in tandom, and therefore need a tensor with 2^3 indices, we have

$$\Lambda_{i_1 i_2 i_3 i_4 j_1 j_2 j_3 j_4} E_{i_1 j_1} E_{i_2 j_2} E_{i_3 j_3} E_{i_4 j_4}$$

and so we can represent Λ as Λ_{IJ}, where I, J are 2 by 2 matrices.

Similarly, for $\alpha_{ijk} E_i E_j E_k$ for 0-categoric 3-tensors, we can instead consider

$$\Omega_{I_{AB} J_{CD} K_{EF}}$$

for natural tensor constructions over function space associated to cybernetics, where A, B, C, D, E, F are 3 by 3 matrices, and I, J, K are likewise 3 by 3 matrices indexed by the prior 3 by 3 matrices (where of course we are adopting the convention that we are 'multiplying' these indices together in said object). Then we have a tensor construction of order 3^5, associated to the relevant constructions concerning cybernetic tensors defined on function space.

Here now $Inv^{(1)}$ for Ω is constructed in the following way:

$$\Gamma^{K_{PQ}L_{RS}}_{I_{AB}J_{CD}K_{EF}} := \langle \nabla_K I, \nabla_L J, K \rangle_\Omega$$

There is a natural invariant

$$Inv^{(1)}(\Omega) := \Omega_{I_1I_2I_3}\Omega_{J_1J_2J_3}\Omega_{K_1K_2K_3}\Omega_{L_1L_2L_3}\Omega_{M_1M_2M_3}\Gamma_{I_1I_2I_3A_1A_2}\Gamma_{J_1J_2J_3A_3A_4}\Gamma_{K_1K_2K_3A_5A_1}\Gamma_{L_1L_2L_3A_2A_3}\Gamma_{M_1M_2M_3A_4A_5}$$

which is 10th order, as alluded to above.

Then we have a 4-vector of meta-information theories, which naturally allows us to compute by abuse of notation

$$\hat{R}(\Lambda) = Inv^{(2)} \circ Inv^{(1)} \circ R(\Lambda^{(G,H)})$$

as a meta-cybernetic invariant defining the dynamics of ultradrive, where

$$Inv^{(2)}_\tau(m) := \tau_{i_1i_2i_3i_4i_5}\tau_{j_1j_2j_3j_4j_5}\tau_{k_1k_2k_3k_4k_5}\Gamma_{i_1j_1k_1abcd}\Gamma_{i_2j_2k_2efgh}\Gamma_{i_3j_3k_3ijab}\Gamma_{i_4j_4k_5cegi}\Gamma_{i_5j_5k_5dfhj}$$

is a 5th order invariant for a 5-tensor τ.

Consequently in general we are interested in solving a 31st order PDE over a 2^{19} tensor coupled with a 3^5-tensor for cybernetics, and a 5-tensor for meta-cybernetics.

3 Remote sensing

Much of this theory of course is moot if one is driving blind. It is interesting to ask how one would be able to develop remote sensing capability in order to detect matter at significant distance from the soliton. In this section we ponder the answer to this question.

Note that, just as it should be theoretically possible to intuit what is nearby on an indented cloth by measuring the curvature of the cloth, it should be possible to measure what is nearby in space by measuring the curvature of space at a particular location. This gives us an indirect view of data at significant remove to us, and potentially much faster. Note though that we are interested in moving objects. A moving object will alter the geometry and emit a signal, or gravitational wave, indicating how the curvature has changed.

The speed at which signals propagate through a Lorentzian manifold of course is limited, but with more exotic geometric models of space, such as described in [N], a signal will move faster.

Consequently a signal of such type will be measurable via a 3-tensor model of space, whereby the intuition is that one is interested in two points (p, q), and the curvature at p exerted by q, wherein one is considering the first feedback of the force at q by p, hence interacting again with p from q. But rather than being a perturbative correction, as in Feynmann's QED or perturbation theory (see eg [Ab]), we are considering rather a higher order resonance. This is characterised by a 3-tensor.

Then we consider said 3-tensor σ to be defined over $M \times N \times P$, such that $\sigma(m, n, p)$ indicates the tensor interaction between m and n at p, and where

$$\Gamma^{\alpha}_{ijk} := \langle \partial_\alpha E_i, E_j, E_k \rangle$$

where $\{E_i\}$ form a basis for the tangent bundle of $M \times N \times P$.

Just as before, we can define $Inv(\sigma) := \sigma_{ijk}\sigma_{lmn}\Gamma_{ilab}\Gamma_{jmbc}\Gamma_{knca}$ as the information invariant associated to σ, where

$$I := \int_M f|\partial lnf|^3_\sigma dp := \int_M Inv(\sigma(p))dp$$

is the information. Again as before, note that $Inv(\sigma) = 0$ when I is critical, which is a third order PDE.

So this is good for remote sensing in ordinary space. However, we are interested in solitons, so it is natural to consider solitons moving relative to one another.

Then we are interested in a 5-tensor τ defined over $(M_1 \times N_1) \times (M_2 \times N_2) \times P$, such that $\tau(m_1, n_1, m_2, n_2, p)$ is the signal at p of the coordinates (m_i, n_i) of two solitons moving relative to one another.

We can then build Christoffel symbols, information invariants, and determine dynamics in a fairly logical and obvious way. This time the invariant will take the form

$$Inv(\tau) := \tau_{i_1i_2i_3i_4i_5}\tau_{j_1j_2j_3j_4j_5}\tau_{k_1k_2k_3k_4k_5}\Gamma_{i_1j_1k_1abcd}\Gamma_{i_2j_2k_2efgh}\Gamma_{i_3j_3k_3ijab}\Gamma_{i_4j_4k_5cegi}\Gamma_{i_5j_5k_5dfhj}$$

and it will form a 10th order PDE as a geometric invariant arising from a natural information functional.

Christoffel symbols Γ can take the form

$$\Gamma^{pq}_{ijklm} = \langle \nabla_{C_{pq}} A_{ij}, w_k, B_{lm} \rangle_\tau$$

Note however that there are different theories one can construct, where the connection is applied to different components of the inner product.

In particular, we might consider

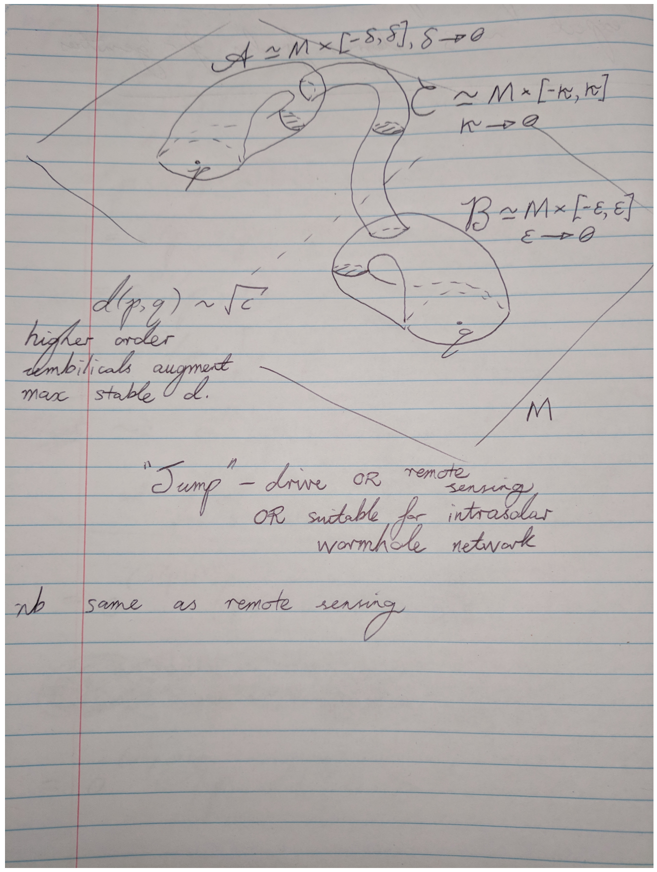
$$\begin{aligned}
\Gamma^{pq}_{ijklm} &= \langle \nabla_C A, w, B \rangle_\tau \\
&= \langle A, \nabla_C w, B \rangle_{\tau^{ac}} \\
&= \langle A, w, \nabla_C B \rangle_{\tau^{c^2}} \\
&= \langle \nabla_{C^T} A, w, B \rangle_{\tau^b} \\
&= \langle A, \nabla_{C^T} w, B \rangle_{\tau^{abc}} \\
&= \langle A, w, \nabla_{C^T} B \rangle_{\tau^{c^2 b}}
\end{aligned} \tag{1}$$

where $S_3 = \{a, b, c | a^2 = b^2 = c^3 = 1\}$ is the symmetric group of order 3, and $\nabla_C w$, the action of a component of an element in the jet bundle on an object in a tangent bundle, is computed in a natural way.

Here we follow the convention that a is called whenever a tangent bundle rather than the first jet bundle is used, c is called according to the position in the tuple that the connection is applied, and b is called whenever a jet bundle rather than the first jet bundle is used.

Then τ^{S_3} form six different geometries that can be used for remote sensing, with six different types of dynamics.

Interestingly, this setup is totally equivalent to what is required to consider building an intrasolar wormhole network, or alternatively understand the dynamics of an elementary 'jump' drive. To consider such, we build an aperture at a particular point and attach an infinitesimal wormhole onto it. Then we create an umbilical on that, and sense a region generically at some distance perhaps at maximal stable distance $\sim \sqrt{cln(c)}$ away, say, where c is a light year, so of the order of 16 million kilometres (say). We attach the free end of this umbilical to a target aperture. Then for travel from destination to target, one injects through the initial aperture, and ejects at the target aperture, rather like in the following diagram:



Note that the above considerations only apply to vehicles travelling in a first order warp. For a second order warp, one must needs consider more complex dynamics. I will not discuss such here in detail, but will indicate briefly what this would entail.

Briefly, we are interested in some form of 7-tensor τ defined over $(M_1 \times N_1 \times P_1) \times (M_2 \times N_2 \times P_2) \times (M_3 \times N_3 \times P_3) \times (M_4 \times N_4 \times P_4) \times (M_5 \times N_5) \times (M_6 \times N_6) \times M_7$, such that $\tau(m_1, m_2, \cdots, m_7, n_1, n_2, \cdots, n_6, p_1, p_2, p_3, p_4)$ is the signal at m_7 of two solitons (m_5, n_5) and (m_6, n_6) moving relative to each other, each in turn influenced relative to the coordinates $(m_1, n_1, p_1), (m_2, n_2, p_2)$ and $(m_3, n_3, p_3), (m_4, n_4, p_4)$ respectively of two meta-solitons moving relative to one another.

Christoffel symbols Γ take the form

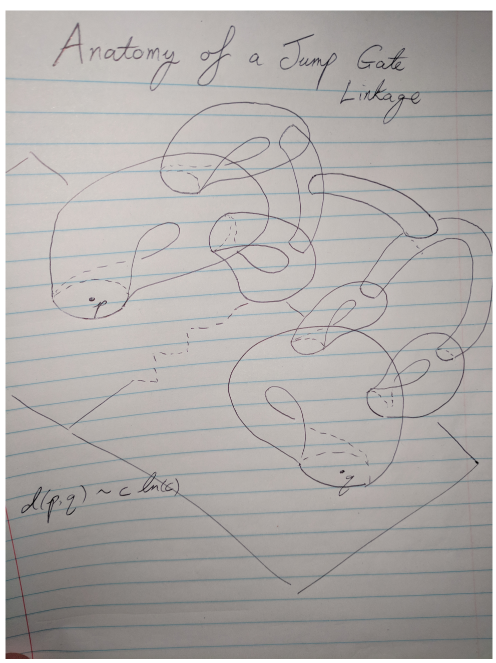
$$\Gamma^{IJ}_{ijklmTRSUQVPW} \langle \nabla_{\gamma_{IJ}} \alpha_{TR}, \epsilon_{QV}, A_{ij}, w_k, B_{lm}, \delta_{PW}, \beta_{SU} \rangle_\tau$$

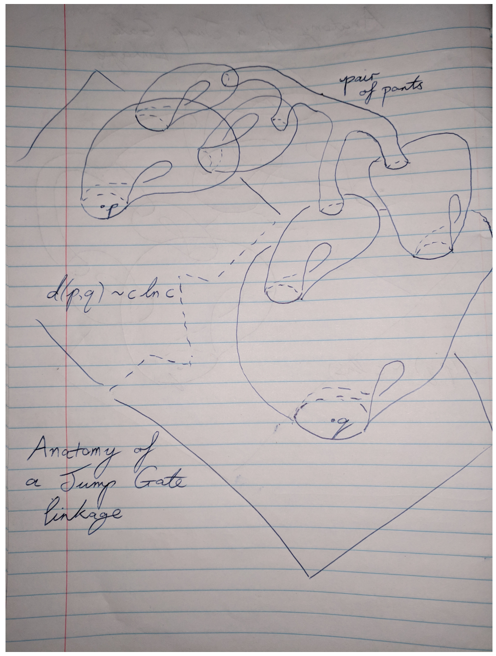
where $A, B \in J^{(1)}(M \times N)$, $\alpha, \beta, \gamma, \delta, \epsilon \in J^{(2)}(M \times N \times P)$, $w \in TM$.

Note that as before there are different theories one can construct. These are generated by S_7 acting on the above construct in an analogous way to before. These give arise to different geometries that can be used for remote sensing.

For analogous aperture distance limitations / calculations, one might anticipate being able to extend an aperture across distances of order $cln(c)$ (an additional factor of $\sqrt{cln(c)}$), which might render such practical to span interstellar distances in a nearby neighbourhood (maybe up to 30 to 40 light years). Such might well necessitate constructing 'jump gates' at particular exit points in a solar system, for craft to use to bootstrap the jump, as the energies required could be quite large.

For reference I have provided a couple of illustrations qualitatively illustrating roughly how the 7-tensor (3-cybernetic / 'meta-meta-cybernetic theory') above roughly corresponds to jump gate linkages. In such way, the following might go some way further to providing a more heuristic understanding of what is required to manipulate jump gate physics.





In order of complexity, we expect engineering challenge to ramp up in the following sequence:

- First order soliton / 'warp' drive
- Intrasolar wormhole networks
- Second order soliton / 'warp' drive
- Interstellar wormhole networks

For the first two, one would likely need at least quantum computers for control circuitry. For the latter two, one would likely need tetra-computers [Go4]. Should such not be sufficient, one might need tetra-computers for the first two, and penta-computers for the latter pair [1].

[1]Here a penta-computer is a device with three levels of stratification of its quantum states, wherein computational capacity grows as the pentation of 2 with respect to the number of atomic components or gates.

4 Endnotes

4.1 Digression on number sequences

If $p : N \to N$ is the prime number sequence, then

$$p(1) = 2$$
$$p(2) = \circ(p; 2)(1) = \circ(p; \circ(p; 1)) = \circ^{(2)}(p; 2) = 3$$
$$p(3) = \circ(p; 3)(1) = \circ(p; \circ(p; \circ(p; 1))) = \circ^{(2)}(p; 3) = 5$$
$$p(5) = \circ(p; 5)(1) = \circ^{(2)}(p; [\circ(p; 1)]^2) = \circ^{(\circ(p;1))}(p; \wedge(\circ(p; 1), \circ(p; 1))) = 31$$

Next logical prime after 31? Expect $\circ^{(2)}$, $\wedge^{(2)}$ to be used.

4.2 Back of the envelope calculations

We consider say the travel time to Trappist-1 ($\sim$40 light years from Earth) given a few scenarios:

- Travelling at 10000km/h (as is feasible with a relatively standard rocket engine)
- Travelling at 0.1c (as is feasible with a fusion drive)

and either

- Travelling in a first order warped spacefilling curve soliton
- Travelling in a second order warped spacefilling curve soliton

Next we consider the travel time to Mars and to Pluto given the scenario of travelling at 10000km/h in a first order warped spacefilling curve soliton.

A key motivator for this paper was to examine the overall feasibility and complexity of what would be required to travel interstellar distances at speed. In this section we adopt the convention / conjecture that effective speed in a warp of stage n is a factor of c^n faster, where c is the speed of light.

Then we can quickly make a couple of quick corollaries of such a statement:

- At 0.1c, we could reach Trappist-1 in 500 days in a first order warp.
- At the same speed, travelling in a second order warp, we could travel the same distance in 1.3 seconds.

At a more reasonable speed in relative space (10000km/h) - note that 0.1c is approximately 10^8 km/h, as c is 30,000,000m/s, or 100 million km/h. Therefore to decrease speed to 10^4 km/h requires a 10000-fold increase in travel time, so:

- At 10000km/h, we could reach Trappist-1 in $5 * 10^6$ days, or about 13 700 years in a first order warp.
- At 10000km/h, we could reach Trappist-1 in 3.6 hours in a second order warp, which seems reasonable.

For travelling to Mars - generically say 100 million kilometres, would require, at 10000km/h:

- 1.15 years if travelling in ordinary space.
- 1.1 seconds if travelling in a first order warp, which makes 10000km/h seem a bit fast.
- 3.62 minutes if travelling in a first order warp at 50km/h, which is still fast but a little more reasonable.
- 36 minutes if travelling in a first order warp at 5km/h, which seems reasonable.

For travelling to Pluto - generically say 10 billion kilometres away, would require:

- 115 years if travelling at 10000km/h in ordinary space.
- 100 seconds if travelling in a first order warp at 10000km/h
- 5.6 hours if travelling in a first order warp at 50km/h

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4.3 Directly applicable

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