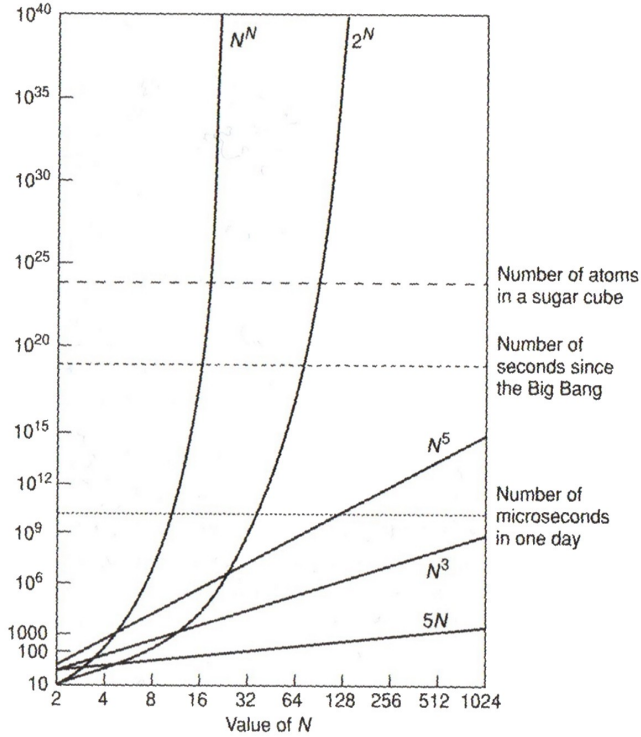**Fig. 4.8** The rate of growth of the quantities $5N$, N^3, N^5, 2^N, and N^N as N increases, together with some other large numbers for reference.

Illustration of exponential growth in dealing with
increasing parameters without selection
- from 'Impossibility' by Professor John Barrow

JLIAT "C"

C = The complete sequence of possible variations of the 7 notes from middle C in the C Major scale.

This project is simply called C. It consists of creating ALL sequences of the scale of C major with the base note and the 6 notes following… Produced by specially developed computer programs to write and play the midi note sequences…
.. in this release the full score, a midi sequence and Audio CD of the first hour of the full 480 hour sequence.

C, D, E, F, G, A, and B

See http://en.wikipedia.org/wiki/C_major for more detail on the background and history of the scale.

(note: a 12 tone scale or any much larger than 7 notes as will be seen rapidly becomes unrealisable- hence a scale of 7 notes...)

Impossible Musics…

In an earlier work I explored the idea of all possible Audio CDs. Briefly every CD is made from bit patterns, 1s and 0s, so there is in audio Cds a finite number of possible arrangements of 1s and 0s, which gives all possible CDs. The number is huge.

All possible CDs… an audio CD stores music by patterns of bits, each audio sample is 16 bits, and each second of sound has 44100 samples, so 16 x 44100 gives us a second of sound. Multiply by two for stereo, and then by 60, for a minute, then by 74, 74 minutes being the old specification of the maximum duration of an audio CD. The fact you can get longer and different formats is for my purpose irrelevant here. Multiply 16 x 44100 x 2 x 60 x 74 and we get 6265728000. That is bits, and if you convert this to bytes, you get around 740 megabytes, that is about right, it is the storage capacity of CDRs. What follows is that there are 2 to the power 6265728000 possible CDs, and no more (in this format). Written mathematically $2\char94 6265728000$.

This number is not possible to manufacture as it is many more times the magnitude of the whole universe. The estimated number of particles in the universe is $10\char9480$, $2\char946265728000$ is about $10\char942000000000$!

Even with the first few seconds of an Audio CD if we want all possible variations it not possible, 16 x 44100 is 705600, $2 \char94 705600$ is far far bigger than the number of particles in the known universe… so even realizing a second of all possible CDs is out of the question.

Moving to a simpler sequence or set of a smaller number of elements an actual realisation would be possible. One option is to use musical notes and explore the possible arrangements and sizes. With this we might begin to approach something realisable.

I decided on the C major scale of only 7 notes excluding the octave note… for reasons of it being a sufficiently complex 'system' – a scale – yet one

which could be totalizeable, i.e. fully realised. Though the theory (and this piece or similar) could apply equally to other scales and tunings, as long as they are fixed and fairly limited.

Even given a very short length of music of 10 notes we have 10^128 possible songs using only the 128 notes supported by midi…. still far too big a number to deal with…. Playing 10^128 notes would not be possible in a human lifetime … Even playing several notes a second the Earth would not exist long enough to complete the 'performance', though some matter might remain in black holes and remnants of burnt out suns at its "completion" time …

The Major / Minor scales found in western music use an 8 note octave in which the last note is the same as the base note shifted an octave higher. This gives a sequence of seven different notes, and this is (just!) a realisable sequence. 7 is a very much more manageable number, 7^7 is 823543. We need a key and scale and for simplicity and ease of expression I chose C major. So now lets take the octave of C major of just 7 notes starting at Middle C (midi 60) – only 7 as the 8th is C again, 7^7 gives 823543 sequence variations of 7 notes which is 5,764,801 notes played sequentially. At 200 B.P.M. this takes 28,824.005 minutes or 20.01667014 days to play…

7^7 is = 823543. This represents the total possible sequences in the octave.

Playing 7 notes as follows…

1	CCCCCCC
2	DCCCCCC
3	ECCCCCC
4	FCCCCCC
5	GCCCCCC
6	ACCCCCC
7	BCCCCCC
8	CDCCCCC
	…
	Until
823543	BBBBBBB

This sequence of notes is without silences or stresses, if these are included as well as the volume range per note of between 0 and 127 the realisation isn't possible. 7^7^128… is not realisable…

It then became a simple matter in the first instance to 'realise' this sequence. To write a computer program to work through all possible combinations and output these as midi data. This midi data can then drive any suitable device to render the notes.

Well a little more than simple given these sizes. Two methods were used, the first program outputs midi data in real time. A recording or 'performance' of this would take 20 continuous days, so an option to perform parts of the sequence was added. Another approach at playing the sequence was also explored. This involved writing a program to produce a midi data file. Such a file could then be parsed in sections without the need to perform the whole piece continuously. This was 'fairly' simple and gave a file of 51,884,032 bytes which unfortunately crashed the midi editor I was using for checking purposes, however Microsoft's Media player does play this length of file. The final midi file output from the program would traverse the sequences in 480 hours, 1 minute and 46 seconds (200.1528019) B.P.M. (Fine tuning across this time period using the software available.)

The real time program was set to trigger notes every 3/10th of a second but in practice runs at around 193 B.P.M. (192.9833333 B.P.M – giving 20.7 days) A recording using the first program in MP3 format would be possible, some 25 gigabytes or around 7 DVD disks. PCM data in wave format suitable for Audio CDs has a maximum size limit of 4 gigabytes, and would take over 340 CDs. Though the time involved may be problematic, it also might be possible to stage a 'human' performance – which would require a team of musicians.

Given this sequence size we can manage to render a performance, if we go to larger scales such as 12 tones we would be dealing with over 12 billion notes or 1,017,819.69 years for a 'complete' performance… Such is the nature of exponential increase – as shown in an excellent illustration from John Barrow's book… he cites the Towers of Hanoi 'game', see http://en.wikipedia.org/wiki/Tower_of_Hanoi, in using 64 disks the task

takes 10^44 billion years… [1] (This whole topic and the problem of practical realisation has many 'metaphysical' repercussions …as well as the more mundane)

Another alternative solution could be realised as the publication of the midi file on a data CD, together with the source code for the two programs and executables (windows).

(The code for handling midi data was not my own and I am grateful for those authors who published these. Unfortunately they must be anonymous as their names are not commented in the code..but Matthew Stride's "Midi Note Generator" was one source)

These programs for windows are available online at www.jliat.com/C/

I explored other realisations:

A realisation of a simple score in which the permutations of such a sequence could be produced. A list of the sequence gives about 3,000 pages and editing these in a word processor was problematic (programs crashed or froze at the sizes involved). A solution to this was to write a program for formatting all the sequences in a text file which then could be edited for printing . This proved to be not only a workable solution but one which could produce the piece as 'an object' of text in under 600 pages.

What **IS** possible, and **HAS** been realised is a fully totalized set of sequences.

The piece exists as a complete work- and a number of consequences and thoughts followed from this, not least those of musical form and aesthetics. Firstly we have in fact actualized something like the 'All Possible CDs' thought experiment. We have produced all possible 7 note sequences in the octave. We have done this algorithmically not randomly like the famous "chimpanzees at typewriters" thought experiment. Any random generation doesn't necessarily generate all possible sequences even if run forever, a random production might miss a sequence or endlessly repeat the same sequence… whereas we have actualised every possible sequence… so any credit I might have in any of the sequences, in terms of 'beauty', 'musical form' etc. I'd have to share with that of the chimpanzee who managed to

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[1] Ibid Impossibility p.102

type Hamlet… as these sequences are not those of deliberate and intentional composition which could garner praise, or not, be subject to judgement or not. This is interesting as the given of a phenomenon such as this work seems to lie outside of 'value'. I've certainly also unintentionally 'made' note sequences of already existing compositions and no doubt in doing so in some cases infringed copyright. (How can number or letter sequences be copyright is another interesting question.)

However (alternatively) we have an 'object' of a totality in its own right- ontologically complete. Any formal or aesthetic predicates which we might place in or on it would be similar to those placed on some mathematics or on nature (reality) itself, if these are regarded as a given sequence within a possible finite/infinite sequence. That is we might look at an object in the natural world and give it an attribute, of beauty or ugliness.

The idea of all possible sequences has a metaphysical analogy in the idea of "All Possible Worlds" which in the case of Leibnitz[2] the choice of the best of these was made by God. This kind of thing also appears in recent cosmology as the result of an infinite universe , a repeating big bang, 'The Bulk' and of the idea of multiverses. "C" represents an full implementation of that kind of thing!

For a much more technically sophisticated idea of such ideas see Max Tegmark's work, however the idea of all iterations of possibilities is still inherent, then "C" is still a good picture.

"I explore physics implications of the *External Reality Hypothesis* (ERH) that there exists an external physical reality completely independent of us humans. I argue that with a sufficiently broad definition of mathematics, it implies the *Mathematical Universe Hypothesis* (MUH) that our physical world is an abstract mathematical structure. I discuss various implications of the ERH and MUH, ranging from standard physics topics like symmetries, irreducible representations, units, free parameters, randomness and initial conditions to broader issues like consciousness, parallel universes and Gödel incompleteness. I hypothesize that only computable and decidable (in

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[2] "there are as many possible worlds as there are series of things that can be conceived that do not imply a contradiction," also 'Spinoza holds that everything that is truly possible will be expressed at some point as God or nature expresses its infinite essence…." Etc.

Gödel's sense) structures exist, which alleviates the cosmological measure problem and may help explain why our physical laws appear so simple. I also comment on the intimate relation between mathematical structures, computations, simulations and physical systems……. The ERH implies that for a description to be complete, it must be well-defined also according to non-human sentient entities (say aliens or future supercomputers) that lack the common understanding of concepts that we humans have evolved, e.g., "particle", "observation" or indeed any other English words. Put differently, such a description must be expressible in a form that is devoid of human "baggage"."[3]

Compare this to some of the motivations in Speculative Realism -

"While often in disagreement over basic philosophical issues, the speculative realist thinkers have a shared resistance to philosophies of human finitude inspired by the tradition of Immanuel Kant.

What unites the four core members of the movement is an attempt to overcome both "correlationism" s well as "philosophies of access". In After Finitude, Meillassoux defines correlationism as "the idea according to which we only ever have access to the correlation between thinking and being, and never to either term considered apart from the other." Philosophies of access are any of those philosophies which privilege the human being over other entities. Both ideas represent forms of anthropocentrism.

All four of the core thinkers within Speculative Realism work to overturn these forms of philosophy which privilege the human being, favouring distinct forms of realism against the dominant forms of idealism in much of contemporary philosophy."[4]

A (acceptable!) criticism of "C" could be it lacks any 'human' directedness and intentionality that any work of art should have. Though it is neither a 'philosophical' object or a theory of Physics, "C" proposes a non-correlational 'music' which has a non-chaotic metaphysics/ontology.

---

[3] http://arxiv.org/abs/0704.0646

[4] http://en.wikipedia.org/wiki/Speculative_realism

The method to ensure the totality was given used a simple iterative sequence.

```
x = 0
For a = 1 To 7
  For b = 1 To 7
    For c = 1 To 7
      For d = 1 To 7
        For e = 1 To 7
          For f = 1 To 7
           For g = 1 To 7
      '
      List1.AddItem (a & " " & b & " " & c & " " & d & " " & e
& " " & f & " " & g)
      '
      x = x + 1
           Next
          Next
        Next
      Next
    Next
  Next
Next
```

Code from preliminary program to print all combinations- the letters are simply variables and do not relate to musical notes at this stage.

Above is the simple algorithm to test sequences. This shows the 'logic' of the expression of the sequence is a development of the sequence of nested iterations and not any other aesthetic or formal 'device'. The 'actuality' of the matrix, like mathematical forms, could be regarded as platonic- i.e. already existing. The algorithm only then 'reveals' this in a form – either as text or sounds. And is only one of many ways of 'revealing' this matrix.

Printed it gives all the permutations of 7 different elements… in this case displayed as digits 1 through 7…

```
1 1 1 1 1 1 1
1 1 1 1 1 1 2
1 1 1 1 1 1 3
1 1 1 1 1 1 4
1 1 1 1 1 1 5
1 1 1 1 1 1 6
1 1 1 1 1 1 7
1 1 1 1 1 2 1
1 1 1 1 1 2 2

Through to

7 7 7 7 7 6 6
7 7 7 7 7 6 7
7 7 7 7 7 7 1
7 7 7 7 7 7 2
7 7 7 7 7 7 3
7 7 7 7 7 7 4
7 7 7 7 7 7 5
7 7 7 7 7 7 6
7 7 7 7 7 7 7
```

The use of an octave in the Major Scale limited to 7 notes, not repeating the C above (C6) is in effect very similar to a base 8 number system, or Octal.

1 2 3 4 5 6 7 10 10 = (8 + 0 decimal) 11 (8+1 decimal)

Any given number base 'automatically' (a priori) generates its full and infinite potential.

Sequence members	Number of sequences	Number of elements	Time in minutes to complete all sequences	Hours	Days	Years
2,2^2	4	8	0.04	0.00	0.00	0.00
3,3^3	27	81	0.41	0.01	0.00	0.00
4,4^4	256	1,024	5.12	0.09	0.00	0.00
5,5^5	3,125	15,625	78.13	1.30	0.05	0.00
6,6^6	46,656	279,936	1,399.68	23.33	0.97	0.00
7,7^7	823,543	5,764,801	28,824.01	480.40	20.02	0.05
8,8^8	16,777,216	134,217,728	671,088.64	11,184.81	466.03	1.28
9,9^9	387,420,489	3,486,784,401	17,433,922.01	290,565.37	12,106.89	33.17
10,10^10	10,000,000,000	100,000,000,000	500,000,000.00	8,333,333.33	347,222.22	951.29
11,11^11	285,311,670,611	3,138,428,376,721	15,692,141,883.61	261,535,698.06	10,897,320.75	29,855.67
12,12^12	8,916,100,448,256	106,993,205,379,072	534,966,026,895.36	8,916,100,448.26	371,504,185.34	1,017,819.69

Sequence members		Time in Days @ 200 BPM to complete all sequences	Time in years @ 200 BPM to complete all sequences
2	2^2	0.00	0.00
3	3^3	0.00	0.00
4	4^4	0.00	0.00
5	5^5	0.05	0.00
6	6^6	0.97	0.00
7	7^7	20.02	0.05
8	8^8	466.03	1.28
9	9^9	12,106.89	33.17
10	10^10	347,222.22	951.29
11	11^11	10,897,320.75	29,855.67
12	12^12	371,504,185.34	1,017,819.69

This detail gives a clearer indication of the 'realisable' boundary.

The resultant matrix – (of 823543 possible total states in our case) can also be regarded as a model multiverse where each line of the matrix represents a possible state, or possible universe. In doing so this *pictures* why most sequences (universes) appear random and chaotic but also why others do not… others seem to have logical sequences…

```
4 3 2 4 7 3 7
4 4 4 4 4 4 4
1 2 3 4 5 6 7
1 2 1 2 1 2 1
3 5 1 6 5 2 6
```

In our 7 note universe we find recognisable 'patterns' and also sequences which are not recognisable. It is important to note that every possible pattern is 'realised' a priori. There can be no novelty in the sequence itself, only in our perception of it. Likewise there are **no** causal relations….

We might think one sequence generates the next., but this is only the method I happen to have chosen to reveal all the sequences… other methods will produce different 'sequences'.. the matrix can be arbitrarily displayed

```
1111411
1121111
1151111
1111131
```

In practice this would be difficult to create with the certainty of displaying all possibilities, however it would give a better sense of the arbitrary totality of a 7^7 sequence.

Here I use the characters 1,2,3,4,5,6,7… and no zero, adding a zero would give an 8 character matrix… and the sequence 0,1,2,3,4,5,6 might be confusing but would 'work' as would any sequence of 7 differing symbols, in the case of music C,D,E,F,G,A,B or

For a = 1 To 7
  For b = 1 To 7
    ETC.

Generates the sequence in our case…

Looking at this sequence

1111117
1111121
1111122

It might appear that 1111117 is the 'cause' of what follows 1111121… and in counting that might be true. But counting only enumerates what is in effect already 'there'. To postulate 7^7, already then has 1111121 at the same time (a timeless time) as 1111117 and all the other sequences. Neither any sequence depends on or is caused by another…

Any sequence if seen as a development within a column cannot in fact be a development. From the reality of the whole matrix no such development, or any development, cause, effect, exists. It is simply a totality. Although the appearance of a sequence is 'real' its reality is only an 'appearance'. And such appearances can be described- logically 1111117 + 1 is 1111121 in our demonstration, so we could say in our 'realisation' 1111121 is 'caused by' 1111117 + 1… but in the total reality it is not. Someone who constructs the matrix differently…

7777777
7777776
7777775

or randomly, will see completely different causal relations… the given totality remains the same. Something for me here seems to resonate with the different time sequences in Einstein's Relativity Theory ..

In physics, the relativity of simultaneity is the concept that distant simultaneity – whether two spatially separated events occur at the same time – is not absolute, but depends on the observer's reference frame.
(http://en.wikipedia.org/wiki/Relativity_of_simultaneity)

However within the matrix, as a given, there is no time at all. All 'events' are not even immediate but a priori. There actually are no events unless 'we' create them… *(for more on this you might like to see "The End Of Time: The Next Revolution in Our Understanding of the Universe" by Julian Barbour)*

The actual note sequences similarly 'reveal' sequences…. 'Words' and even seeming rhyming sequences…

```
"DEADDEA"

FACEDAF GACEDAF AACEDAF BACEDAF


CFAACEA DFAACEA EFAACEA FFAACEA GFAACEA AFAACEA BFAACEA
CGAACEA DGAACEA EGAACEA FGAACEA GGAACEA AGAACEA BGAACEA
CAAACEA DAAACEA EAAACEA FAAACEA GAAACEA AAAACEA BAAACEA
CBAACEA DBAACEA EBAACEA FBAACEA GBAACEA ABAACEA BBAACEA
CCBACEA DCBACEA ECBACEA FCBACEA GCBACEA ACBACEA BCBACEA
CDBACEA DDBACEA EDBACEA FDBACEA GDBACEA ADBACEA BDBACEA
CEBACEA DEBACEA EEBACEA FEBACEA GEBACEA AEBACEA BEBACEA
CFBACEA DFBACEA EFBACEA FFBACEA GFBACEA AFBACEA BFBACEA
CGBACEA DGBACEA EGBACEA FGBACEA GGBACEA AGBACEA BGBACEA
CABACEA DABACEA EABACEA FABACEA GABACEA AABACEA BABACEA
CBBACEA DBBACEA EBBACEA FBBACEA GBBACEA ABBACEA BBBACEA
CCCBCEA
```

Within the sum total of all possible combinations there might be seeming order in moments of a totality which likewise is 'seemingly' mostly meaningless chaos. Both 'meaning' and 'chaos' are (human?) perceptive attributes which do not actually exist within the totality of the matrix.

A criticism might be that 'developmental' patterns are a result of the method of producing the matrix, the algorithm of nested iterations. This is true but any metaphysical categorization outside of each sequence is just that. The total matrix exists as 7^7, in any particular order. I could sort or randomize the sequences, pattern might still be found, but that amounts to metaphysical speculation. The actuality of the matrix is immediate, only its physical construction in a world of time and space is a sequence needed. The reality of the matrix no more depends on its existence, its reality as it

does on some light by which to read it, or sound by which to hear it. The important sequences are those within the 7 notes, here there will be patterns actually formed, but still as 'meaningful' as any random sequences. A pattern might represent a stable universe, a lack of any pattern an 'unstable' occurrence. Again these predicates, 'stable', 'unstable', are human predicates or perceptions and ones made from the vantage point of a stability, that is being in a relatively stable part of *this* universe.

Though the physics of the actual universe of 10^80 particles (yet alone those of greater theoretical ones) are beyond our experience, aesthetic and otherwise, by 'looking' at a relatively small sequence – yet large enough for patterns and order/disorder to appear, we might be looking at, hearing, an artefact, a drawing, a presentation which models a greater reality. After all in some cases artworks can be said to 'picture reality' …. So-

There has been in recent philosophy, of Alain Badiou, Quentin Meillassoux, and Graham Harman amongst others ideas about the non totalability of reality. I'd argue from the realization of this piece here that this may well be only a non totalizable reality – *for us*.

If Mathematics is Platonic then its structures are already there. I feel it a mistake in the recent philosophy to regard infinite sets as non totalizeable, firstly for the simple reason, the childish definition of a set is 'the many treated as one'. A set is as such complete. It might be hard for us to imagine a set which contains an infinity… but infinite sets do exist. And their existence is a priori. However we cannot experience this totality- anymore than experience a timeless reality, but such realities do exist and are totalizable. We have in this piece, "C", produced a totalizable object, it is complete in itself, and accessible, due to its size, to us. No doubt it can be amended, added to etc. but not from within itself- all it's possibilities within itself have been realised. Thus it is a complete real, really real. Nothing escapes it's totality within its ontology, 7^7. This might be problematic for those wishing to claim a non totalizable model for reality. Again, maybe so *for us*. But here in "C", to be, is to be complete. Within the work is a completeness, a completed reality.

 We cannot experience in time timelessness. However in art, in this piece we can in a single object experience the whole totality of C. (C major)

<div align="center">This is complete.</div>

Appendix

This release consists of two disks and two books. This book documents and comments on the process, the other is the full printed 'score' using the note letters.

The Audio CD contains a 'live' recording using the program contained on the 'tools' disk of the first hour of the sequence.

The 'tools' disk contains the two programs used to produce the real time rendition and the midi file. Source code as well as .pdfs of this documentation also can be found together with supporting software used in writing the score and finding sequence chunks for performance.

Source code is also provided. The two main programs were written in Microsoft Visual Basic .Net. the utility programs in VB6.

Copies can also be found here http://www.jliat.com/C/