

Time & Complexity in Music

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Complexity :

- formal value ← algorithmic measure (*objective*)
- esthetic value ← artistic forms
- perceived value (*subjective*)

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A possible quantitative measure of complexity in music?

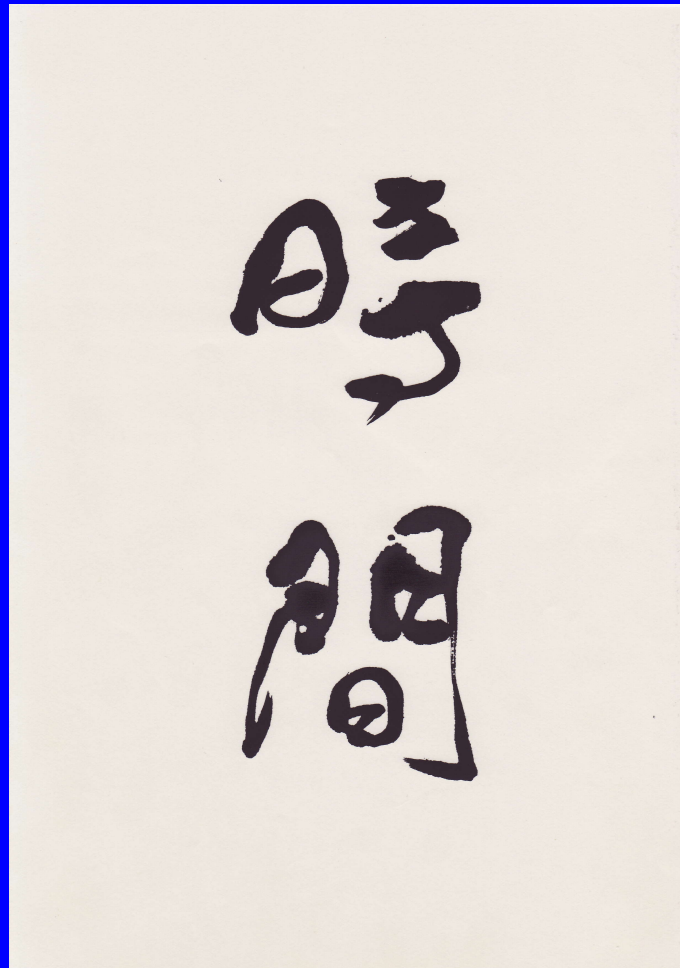
Complexity \leftarrow arrow of time



Erik Satie : "*Le temps passe ... et ne repasse pas*"



arrow of time



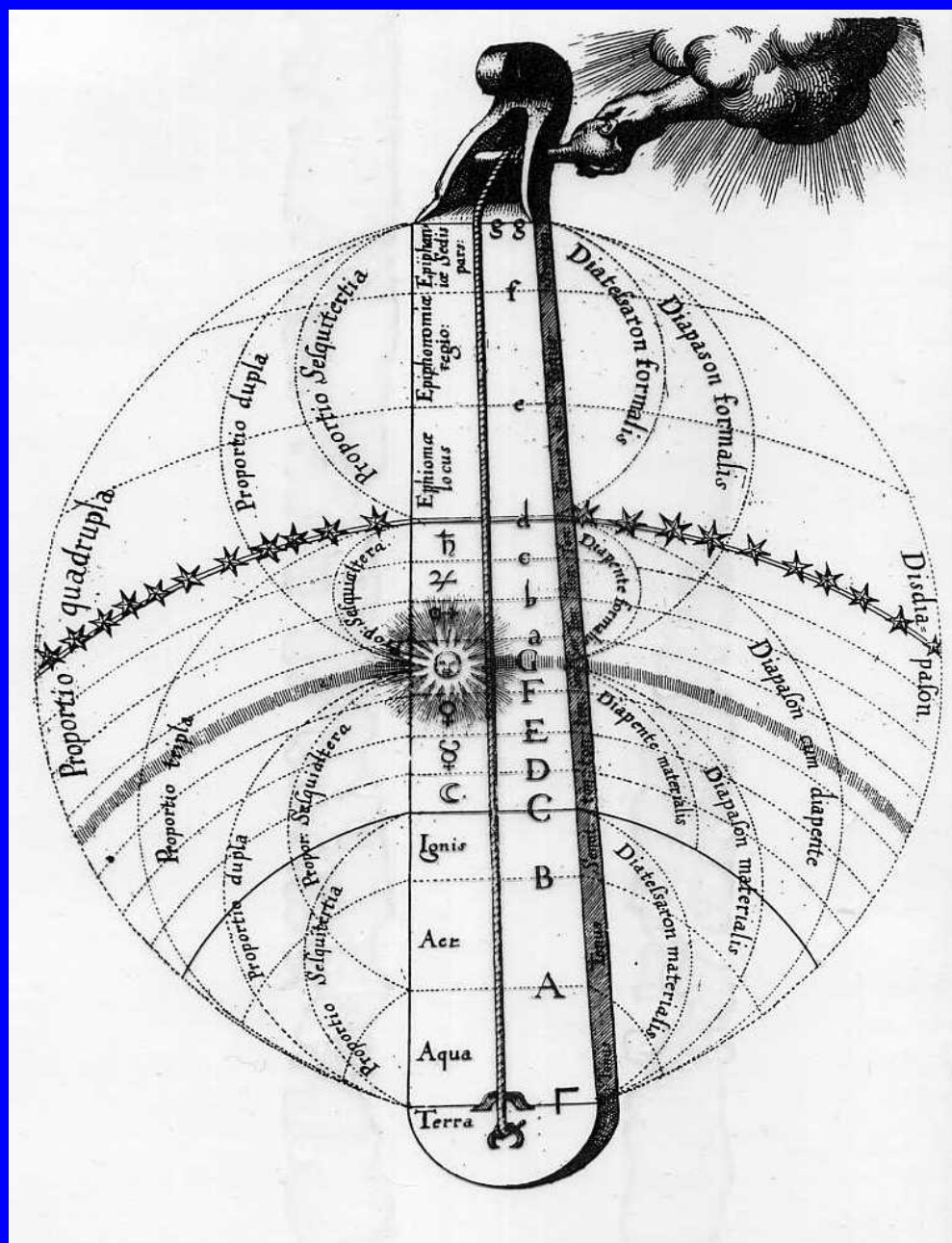
- *Physics* : time t is defined as a point between two intervals \sim *Music*

Pythagoras :
sounds \sim numbers
harmonies \sim ratios

Pythagorean concept \longrightarrow *Quadrivium*

our perception of the universe can be cast in terms of numbers
 \longrightarrow Galileo, Descartes, Kepler

\longrightarrow *Harmonie des Sphères* (Robert Fludd)



19th century :

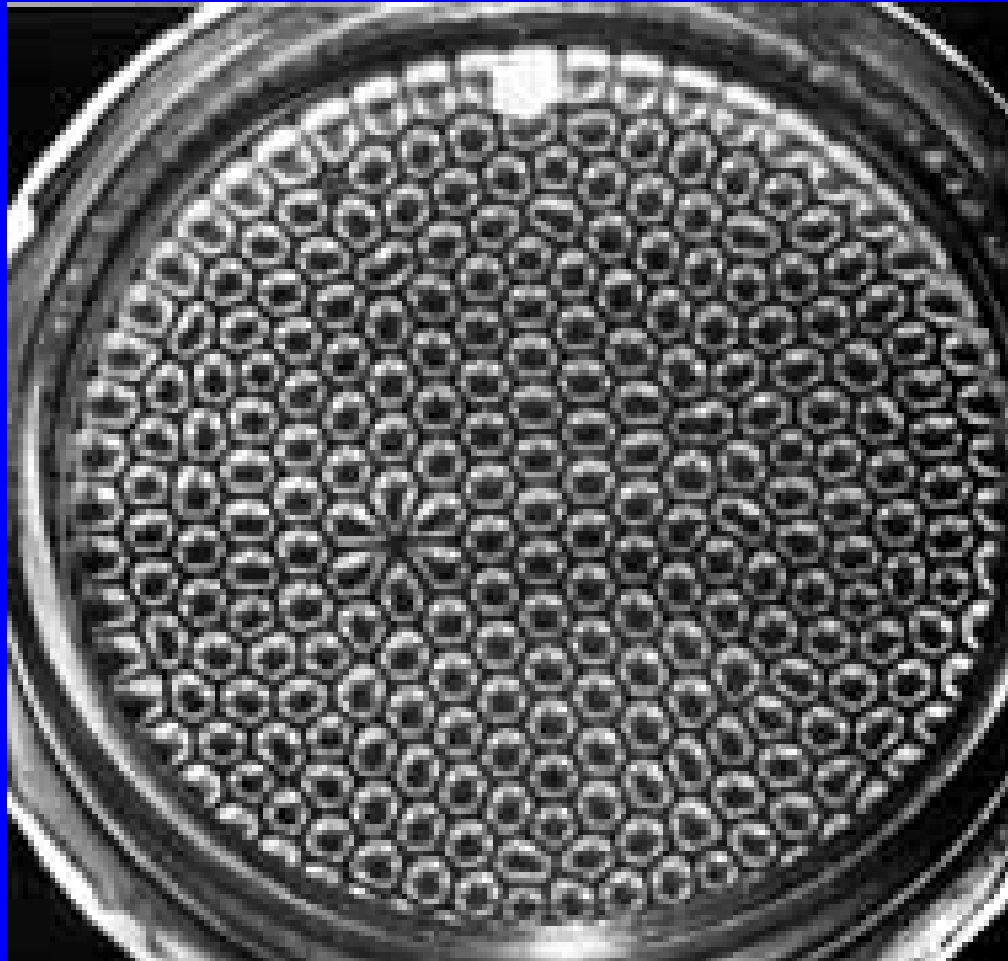
Thermodynamics (Clausius) ; Hydrodynamics (Navier, Stokes)

Statistical Physics of irreversible processes (Boltzmann)

Dynamical Systems theory (Poincaré)

→ 20th century : conceptual notion of time acquires a new meaning in the sense that its status has changed with respect to the classical concept which prevailed in physics until the end of the nineteenth century.

→ Time is viewed as an evolutionary factor - *the arrow of time* - by which natural systems can become organized with the emergence of space- and time-dependent structures.



- Cell pattern in Rayleigh-Bénard convection





JPB - A&C 2008.

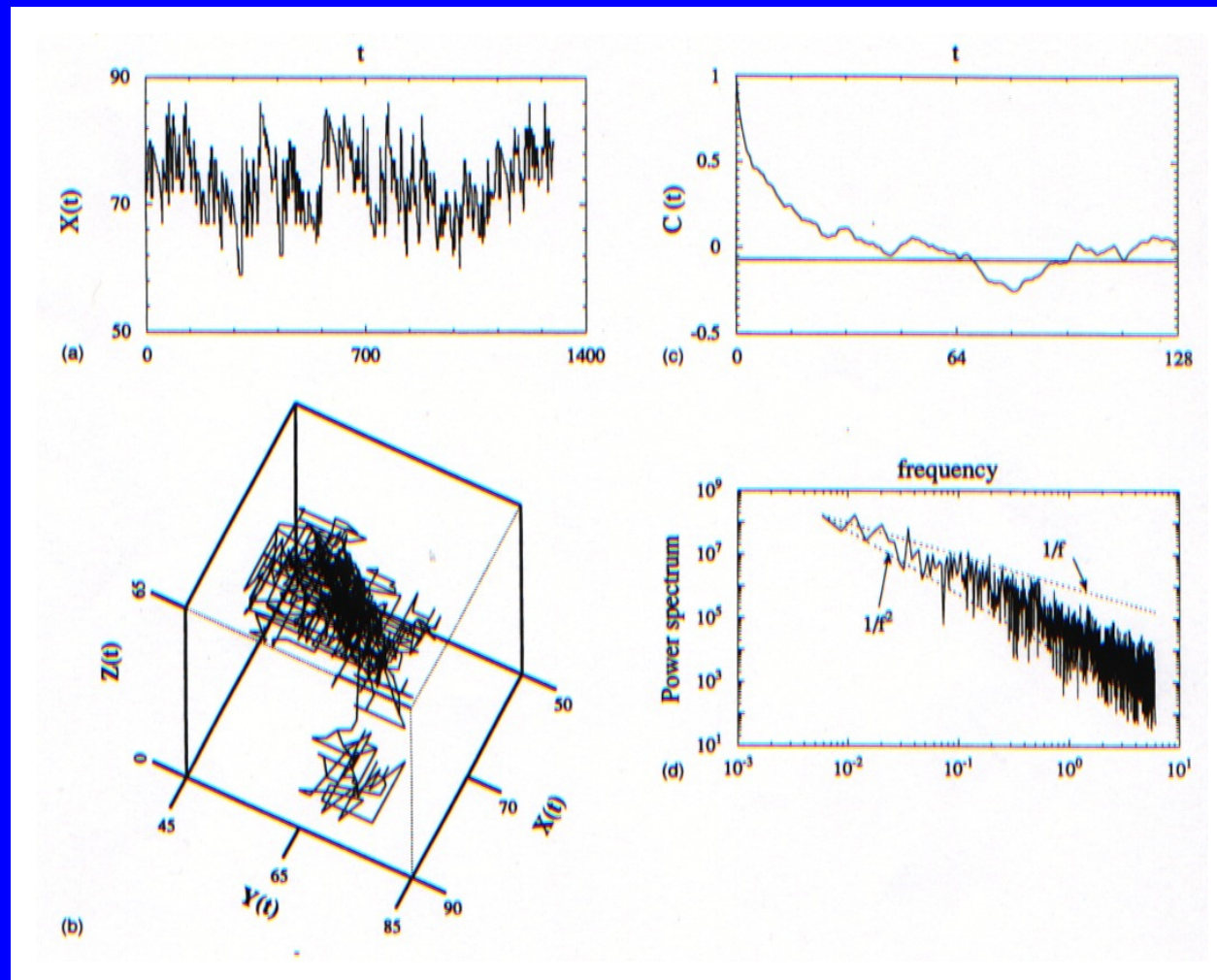
-]Q : complex system ? \longrightarrow systems whose behavior can, under certain conditions, exhibit features that show some degree of complexity according to the criteria used to define complexity.
- Algorithmic definition of complexity. String of bits :
 ... 0110110110110110110110110110110110110110110 ...
 ... 010010100101011001011111101010010101000 ...
 Pointer : $\longrightarrow \Delta \longrightarrow$
 String \longrightarrow input tape of a Turing machine
 \longrightarrow pointer + controller performs computation moving from bit to bit at each tick of the clock to reproduce the string
 \longrightarrow Computation program : length \sim measure of complexity
 \longleftarrow *temporal process*

⇒ Music

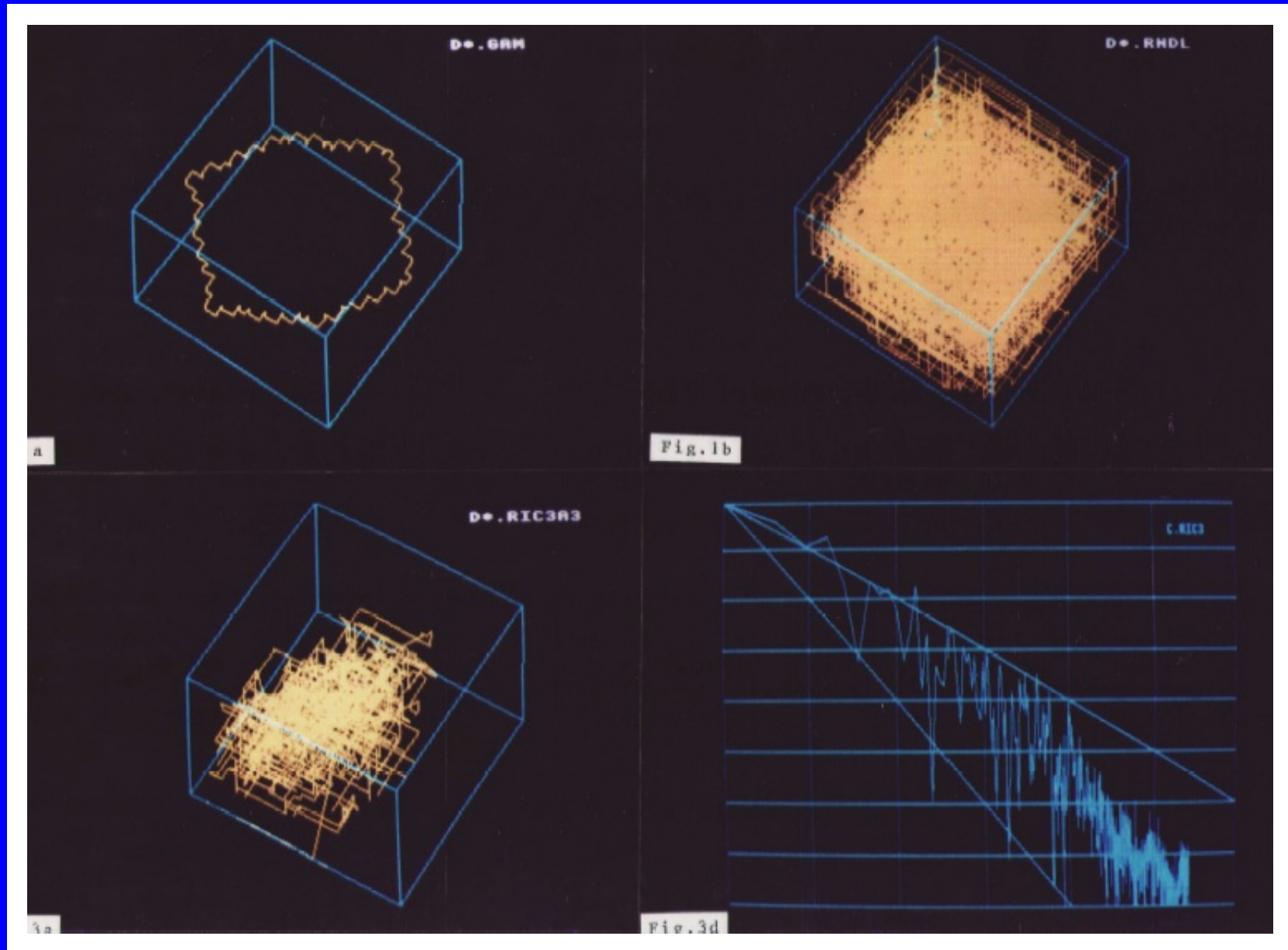
The *arrow of time* is intrinsic to musical expression and a musical sequence can be considered as the time evolution of an acoustic signal (i.e. as a succession of pulses) and therefore as a time series coded in the form of strings of 0's and 1's.

A measure of *complexity* follows from a measurement in time.

Measurements : – time correlation function \leftrightarrow power spectrum
– phase portrait \rightarrow dimensionality (global dynamics)
– information entropy



- J.S. Bach *Ricercare* : (a) $X(t)$; (b) $C(t)$; (c) φ Portrait ; (d) $S(\omega)$



Comments

- (i) Complexity \longleftarrow time behavior
- (ii) Formalization of music dynamics *via* time series
- (iii) \implies Possible measure of complexity
- (iv) Generic value ?

References

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