Parallel Evolution of Electromagnetic Signal Complexity with the Medium Change

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Abstract: Effect of parallel evolution of an electromagnetic signal complexity is shown on signals with different initial complexity for various rules of a medium parameter changing.

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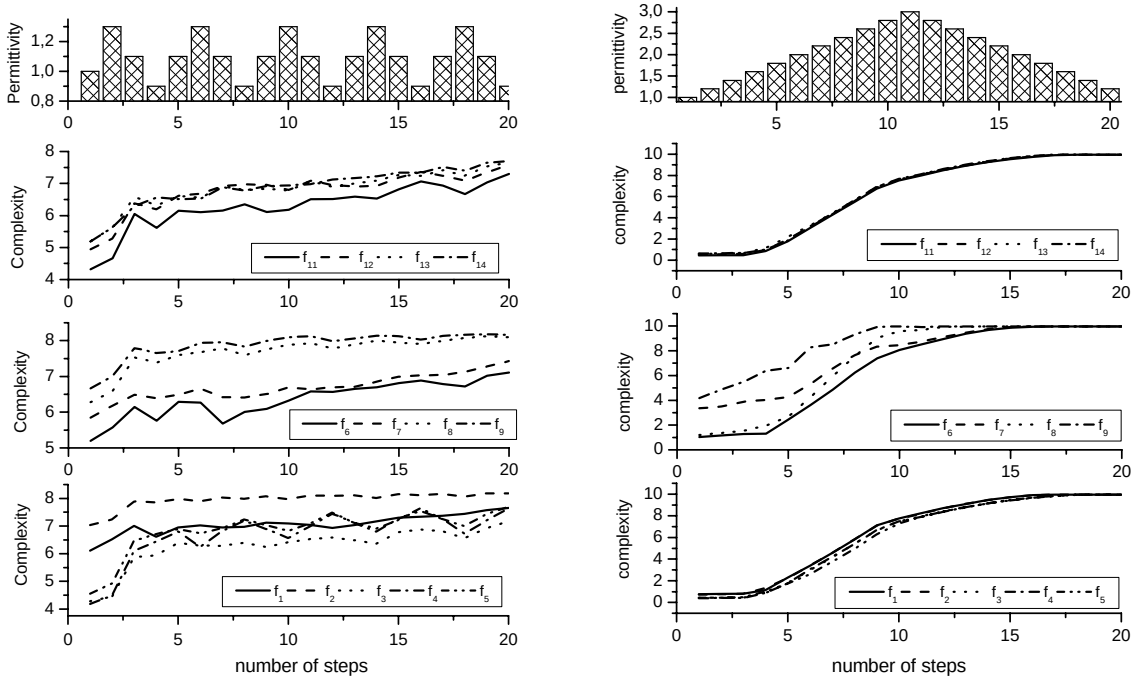
A 'statistical complexity' of an electromagnetic signal is a measure of its information content [J. P. Crutchfield, K. Young, Phys. Rev. Lett., 63, 105-108, 1989]. This measure changes in a time-varying medium when the electromagnetic signal propagates in it. The influence of the subsequent sharp time changes of the medium in the form of rectangular pulses on its complexity has been investigated in previous works [Ruzhytska N.N., A.G.Nerukh, D.A.Nerukh, Optics and Quantum Electronics, 35, 347-364, 2003]. Here, the influence of various laws of the medium change on different initial signals is investigated and an effect of a saturation of a signal complexity is shown.

Three groups of signals with different initial complexity are considered. Signals of a hump-like form: $f_1 = 4\left(e^{-10|t-x|} - e^{-5|t-x|}\right)$; $f_2 = 4(e^{-10|t-x|} - e^{-5|t-x|})\sin 50(t-x)$; $f_3 = e^{-10(t-x)^2}$; $f_4 = e^{-10(t-x)^2}\cos 50(t-x)$; $f_5 = 4e^{-10(t-x)^2}\left(\sin 11(t-x) - \sin 9(t-x)\right)$;

signals of a Gaussian-like form: $f_6 = \frac{1}{50(t-x)^2+1}$; $f_7 = \frac{75(t-x)}{1000(t-x)^2+1}$; $f_8 = \frac{1.7\sin 11(t-x)}{50(t-x)^2+1}$; $f_9 = \frac{75(t-x)\cos 11(t-x)}{1000(t-x)^2+1}$;

and signals described by the Laguerre functions: $f_{11} = 3.5e^{-\alpha(t-x)/2}L_1(t-x)$; $f_{12} = 1.75e^{-\alpha(t-x)/2}L_2(t-x)$; $f_{13} = 0.7e^{-\alpha(t-x)/2}L_3(t-x)$; $f_{14} = (1/3.5)e^{-\alpha(t-x)/2}L_4(t-x)$.

Transformation of the complexity of these signals in the medium which permittivity changes step-wise by an arbitrary rule is shown in Fig. 1. The signal transformation is calculated exactly and its complexity is calculated using Crutchfield's 'computational mechanics' approach [D. Nerukh, G. Karvounis, R. C. Glen, *J. Chem. Phys.*, **117**(21), 9611-9617 (2002)]. The initial value of the signal complexity depends on the signal form and the interval in which this signal is considered. Investigations show that, independently of the initial value, the complexity changes in time in parallel. This is evident for the weak variations of the medium permittivity, Fig. 1a, and implicit in Fig. 1b when the great variation of the permittivity leads to a saturation effect.



a) b)

Fig.1. Evolution of the signal complexity: a) periodic changes and b) a raise and a fall of the permittivity.