Dynamic Modes Maps of Incommensurate Superstructures with Elementary Cell Multiplication

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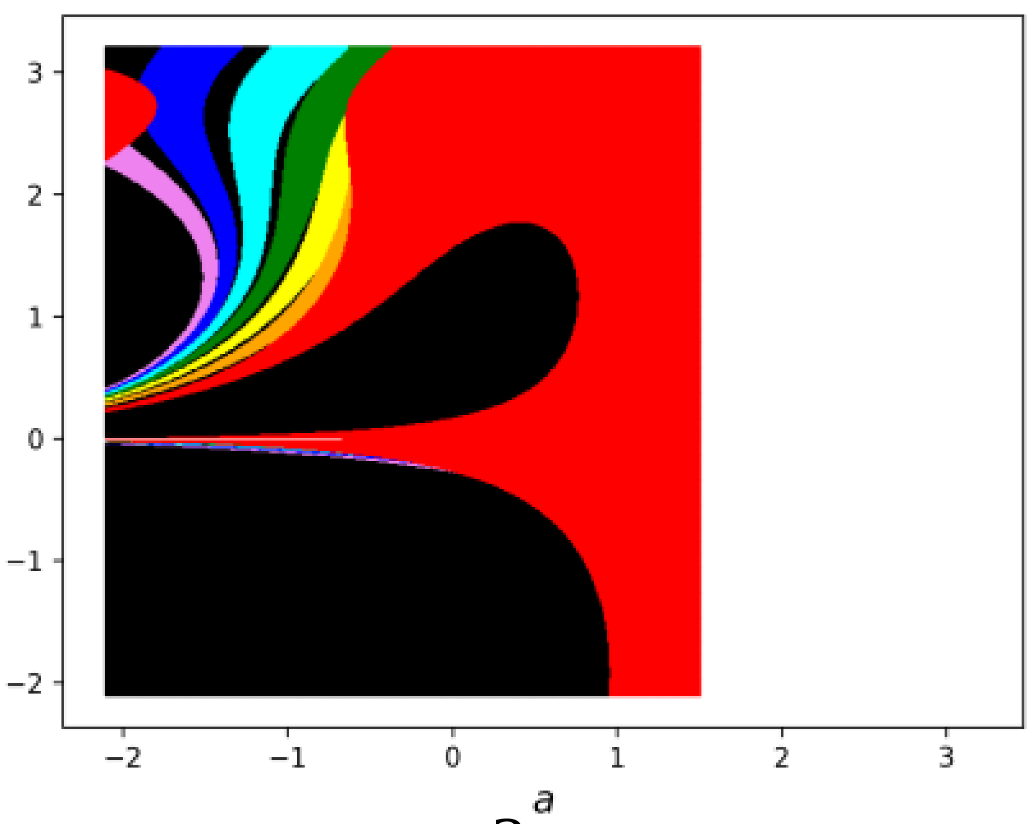
Introduction

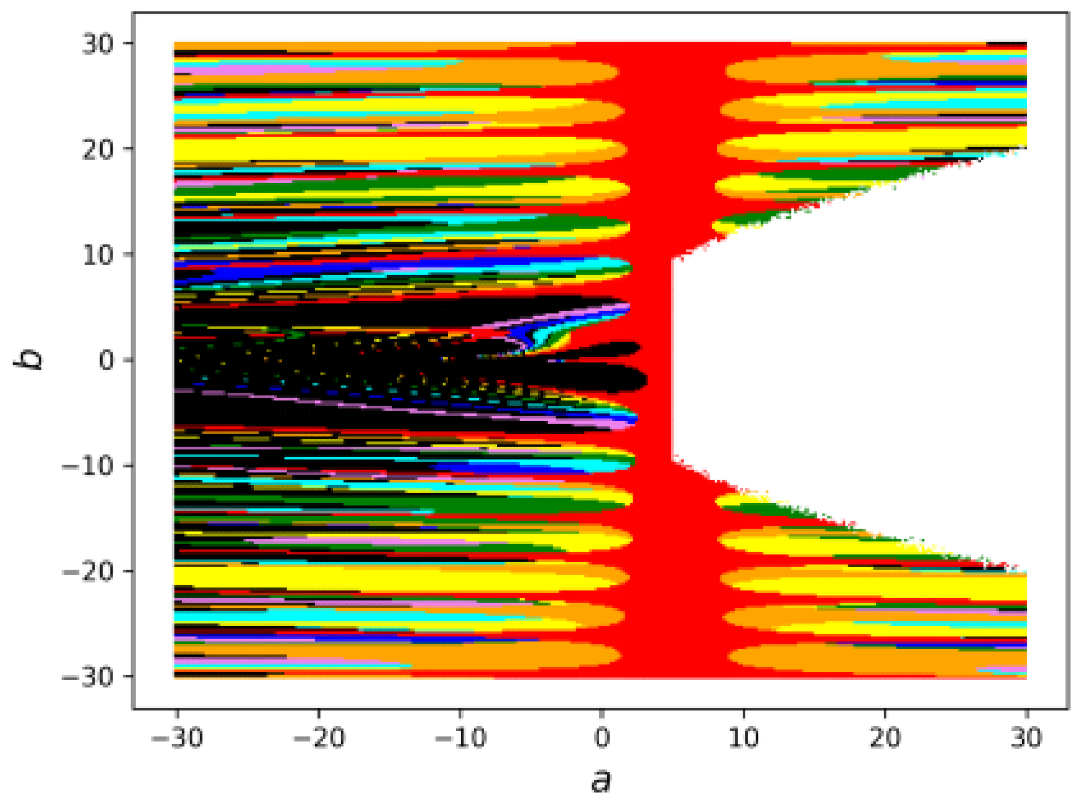
The crystals of the $[N(CH_3)_4]_2MeCl_4$ group (where Me = Zn, Cu, Co, Fe) are characterized by a complex sequence of phase transitions, including the transition to the incommensurate phase with nano-periodicity (with a period of ~ 100÷160 nm). At lower temperatures (i.e., with an increase in anisotropic interaction), the incommensurate superstructure is characterized by a change in its mode from sinusoidal to soliton with a transition to the stochastic mode and the appearance of a chaotic phase. The emerging incommensurate superstructure is characterized by modulation of spontaneous polarization and spontaneous deformation or their sequence. Such a large number of commensurate (long-periodic phases) and sequences of incommensurate phases in these objects stimulated the research of dynamic regime maps of these systems.

Results and Discussion

Creating a dynamic modes map is one of the most visual ways to qualitatively assess a system's behavior. Figure shows the maps of dynamic modes for systems characterized by different multiplication of the elementary cell.



n=3



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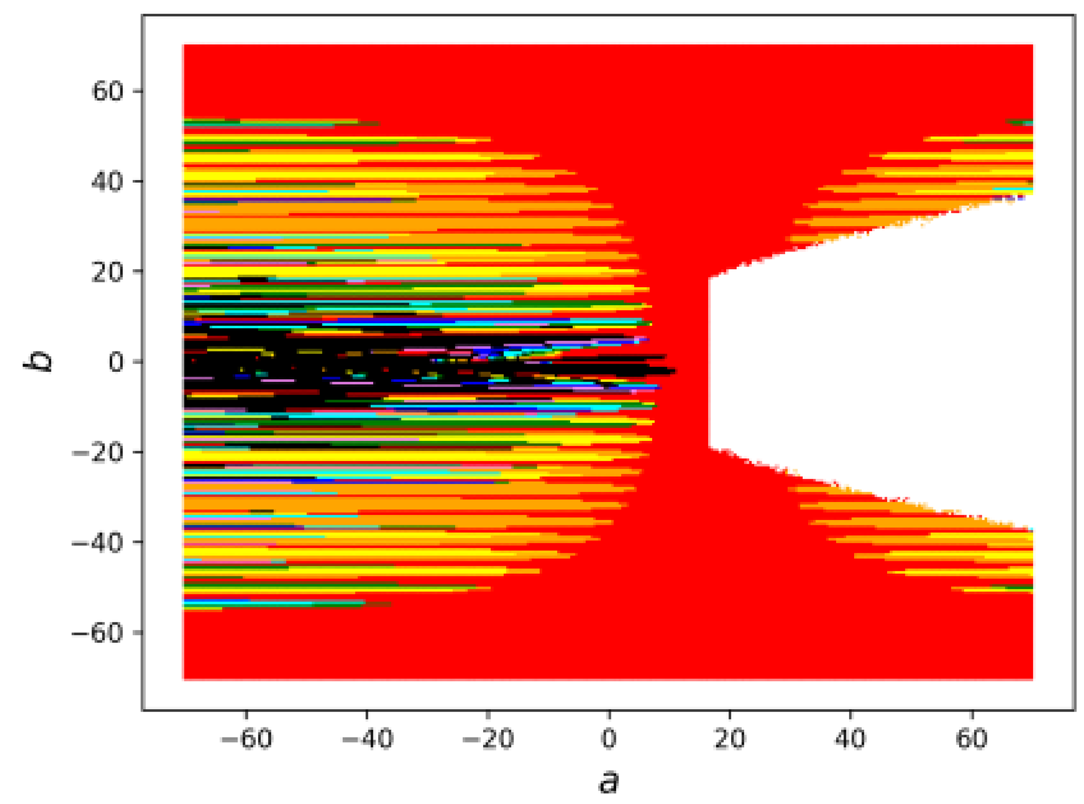

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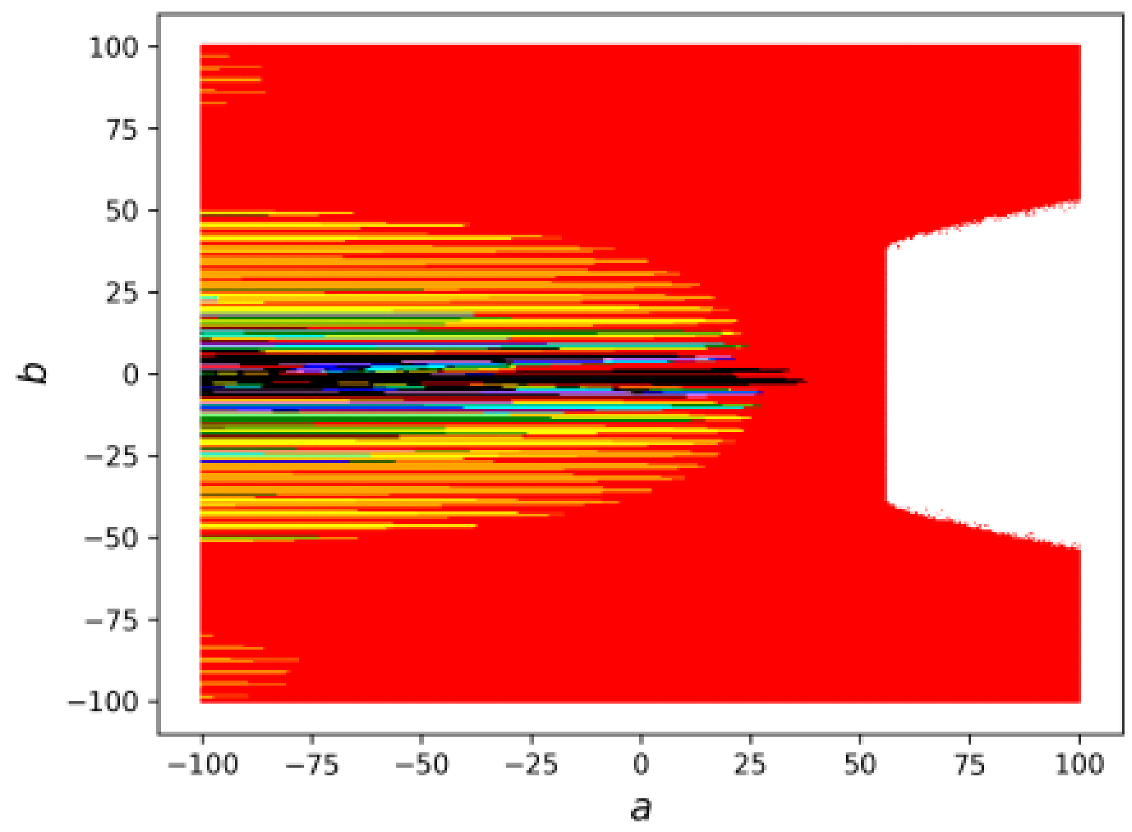

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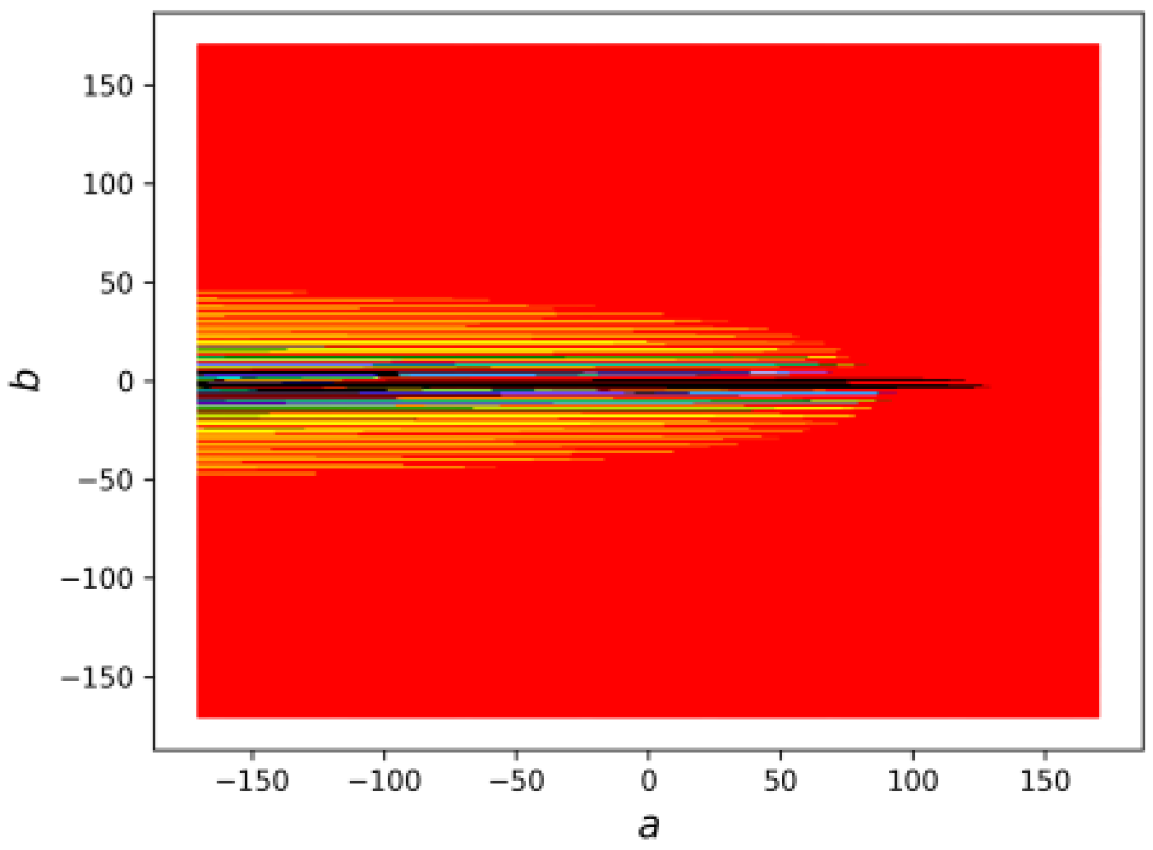

n=7

Fig.1. *Dynamic modes map in the **a** and **b** axes, where **a=K** is the value of the anisotropic interaction parameter described by the Dzialoszynski invariant, and **b=T** is the value of the long-range interaction parameter of the given system.*

In our case, the two-dimensional mappings were defined by recurrence equations as follows: $x_{n+1}=f(x_n,y_n)$; $y_{n+1}=g(x_n,y_n)$. A function describing the amplitude (*R*) of the incommensurability wave or its change (*R*`) was used as a function $f(x_n,y_n)$. The function $g(x_n,y_n)$ acted as a function describing the phase (ϕ) of the incommensurability wave or its change (ϕ`). For this system, the Lyapunov exponents characterized by the most significant changes are described by spatial changes in the order parameter's amplitude (*R*`) and phase (ϕ`). Therefore, Figure 1 shows a two-dimensional mapping, where *R*` and ϕ` were used as functions f() ig(), respectively.

Conclusion

The obtained maps of dynamic modes are characterized by an increase in the number of periodicities, with an increase in the multiplication value of the elementary cell. At *n*=3, when *K* and *T* change (*K*,*T*=0÷1), the existence of two disproportionately modulated phases is traced, which is observed in $[N(CH_3)_4]_2CuCl_4$ crystals. Applying an external field (mechanical or electrical stress) expanded the range of periodicities.