

## What is a crystal? – follow-up

Shelomo I. Ben-Abraham\*

Department of Physics, Ben-Gurion University of the Negev,  
POB 653, IL-84105 Beer-Sheba, Israel

Having started the discussion on “What is a crystal?” and having carefully read all contributions to it, I feel obliged to summarize and draw some (interim) conclusions. Even though written and printed, I consider this to be a roundtable discussion. Hence, I shall refrain from mentioning names and acknowledging credit unless that cannot be avoided.

The “lattice + motif” definition served well two purposes. On one hand, it was a definition in the strict mathematical sense. On the other hand, at the same time it served as a statement of the subject of study in an introductory course to students of physics, chemistry, materials and the like. That cannot be said of the current “definition”. Unfortunately, at this time it seems to be impractical to come up with an adequate substitute.

Some colleagues rightly pointed out the importance of distinguishing between the physics and the mathematics even though they cannot be separated, particularly in theoretical work.

Within the framework of mathematics and corresponding to the present state of our understanding one can readily formulate a **definition of an (ideal) crystal as a structure whose Fourier spectrum contains a discrete part**. However, citing that in an undergraduate class will deter most of the students to take the course or even abandon

their curriculum at all. Thus, for that purpose we must, for the time being, compromise and state or describe, rather than strictly define, what we are going to talk about.

Concerning order, there is general agreement that “order” is an ill-defined concept. Yet, at least on the surface, it is rather intuitive to most undergraduates, as well as to most practicing physicists, chemists etc. and is used by them without deep thinking about its meaning.

Considering all this, I suggest to adopt, until further progress, the formulation of Ron Lifshitz as a statement of the subject:

1. **A crystal is a solid that has long-range positional order.**
2. **Long-range order can be inferred from the existence of Bragg peaks in the Fourier spectrum of the solid.**

When we tell that to an undergraduate class most students will (think they) understand the first part and some will be motivated to think deeper and ask questions by the second part. For us, “the grown-ups”, it will serve as a “working definition” or commentary to the above rigorous definition. At the same time, it will motivate us to inquire and better understand what “order” means.

Returning to mathematics I wish to say that the proposed hierarchy “almost (periodic) crystal  $\supset$  quasi(periodic) crystal  $\supset$  (periodic) crystal” makes very good sense and should be accepted by the whole community. I should add that the majority, against my original suggestion, rightly refused to recognize Thue-Morse-like heterostructures as crystals. Nevertheless, we should expect in the future to encounter more of such structures. If a name should be needed, perhaps they may be called “crystalloids”.

\* e-mail: benabr@bgu.ac.il