The complex diffraction spectra of aperiodic structures

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This contribution is a brief review of the many facets of the complex diffraction spectra of aperiodic structures and of the main physical consequences thereof. The review will start with a reminder on the three different types of diffraction measures : pure point (Bragg peaks), absolutely continuous and singular continuous. The case of self-similar structures generated by inflation rules (substitutions) will then be considered in depth. Substitutions with the Pisot property generate structures with bounded atomic displacements with respect to an average lattice, and to point diffraction spectra of various kinds. Substitutions without the Pisot property generically yield structures with unbounded atomic displacements growing as a power of distance, and singular continuous diffraction spectra with multifractal statistics. The consequences of the above features on the physical properties of aperiodic structures will be illustrated in two situations. One example is the width of the main gaps in electronic spectra in the presence of a weak aperiodic modulation. Another result is a generalization of the Harris criterion predicting whether a weak aperiodicity is relevant or not, in the sense of the renormalization group approach to phase transitions.