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Some interplays between multifractal analysis and Diophantine approximation

Multifractal analysis deals with the determination of the pointwise
regularity of everywhere irregular functions. It is therefore not surprising that many functions which had been proposed as examples or counter-examples of "pathological"functions turned out to be multifractal. What is more remarkable is that they share a common property: their pointwise regularity exponent at a point x depends in a simple way on the Diophantine approximation exponent of x. This is the case of the famous examples that Riemann proposed in his "Habilitationshrift"of functions that are Riemann integrable, but not Cauchy integrable, and which have jumps at rational numbers. It is also the case for a trigonometric series which Riemann proposed as a tentative example of a continuous nowhere differentiable function. Other important examples were obtained as particular cases of Davenport series and, more recently, it was also the case for the Brjuno function which was introduced by Yoccoz because it encapsulates a key information concerning analytic small divisor problems in dimension 1, this function now being one example among an important family. We will show that direct and wavelet methods are in competition or can be combined in order to determine the pointwise regularity exponents of these functions and how these methods explain why their regularity exponents are related with the Diophantine approximation properties of the point considered. Finally, we will mention several open problems concerning the regularity of such functions.