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Many examples of signals and images, which are common in practice, can not be modeled by locally bounded functions. In consequence, standard multifractal analysis, based on the Hölder exponent, can not be applied. Here we present a multifractal analysis based on another quantity, the p-exponent, which can take arbitrarily large negative values, and thus be applied to a broader category of functions. Further, this new exponent can be efficiently characterized by new multiresolution quantities, the p-leaders. We analyze the properties of this exponent, as well as its numerical performance. Further, we use this exponent to characterize the behavior of functions near a singularity in terms of their lacunarity or oscillation. We analyze several examples (deterministic and random) of multifractal functions and study the pertinence of this characterization. Finally, we analyze real data from different domains to assess whether they exhibit this behavior or not.

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