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Structures of random variables and stability of Orlicz spaces

Describing spaces of random variables on a probability space $(\Omega, \mathbb{P})$ as first-order real-valued structures is customarily done imposing an *a priori* restriction to bounded variables in $[0,1]$ (say) or else by generally treating any such space as an ${}^*\mathbb{R}$-valued first-order structure (in the language of nonstandard analysis). We introduce classes of *real*-valued structures that faithfully capture the essence of the classical function spaces $L^p(\Omega)$ and the Orlicz spaces $L^\phi(\Omega)$ (with values in $\mathbb{R}$ or in some Banach space $(\mathcal{X}, \|\cdot\|)$). This perspective casts new light on some foundation aspects of measure theory (e.g., Radon-Nykodim decompositions and the Riesz Representation Theorem) and allows for simple proofs of classical results, including the stability of L^p and of L^ϕ (when ϕ satisfies a "Δ_2-condition" and the Banach space $\mathcal{X}$ is itself stable).