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Elliptic equations in $\mathbb{R}^2$ with exponential growth

Federica Sani *

We discuss the existence of solutions to elliptic equations of the form

$$-\Delta u + V(x)u = f(x,u) \quad \text{in} \quad \mathbb{R}^2, \quad u \in H^1(\mathbb{R}^2) \tag{0.1}$$

where the nonlinear term f has exponential growth with respect to u, and we consider different cases according to the behavior of the potential V at infinity.

When the potential V is constant – or bounded away from zero and large at infinity – the natural space for a variational study of the problem is $H^1(\mathbb{R}^2)$ – or a suitable subspace of $H^1(\mathbb{R}^2)$ – and the maximal growth which can be treated variationally is given by the classical Trudinger-Moser inequality.

When the potential V vanishes at infinity, with a prescribed decay, the problem has a variational structure in suitable (limiting) weighted Sobolev spaces where the maximal growth allowed is determined by a weighted version of the Trudinger-Moser inequality.

*Department of Mathematics, Università degli Studi di Milano, email: federica.sani@unimi.it