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Modularity of some $PGL(2,5)$ representations

Serre's conjecture, proved by Khare and Wintenberger, states that every odd two dimensional mod p representation of the absolute Galois group of the rationals comes from a modular form. This admits a natural generalization to totally real fields, but even the real quadratic case seems completely out of reach. I'll discuss some of the difficulties one encounters and then discuss some new cases that can be proved when $p = 5$. This is joint work with Chandrashekar Khare and Jack Thorne.