Shin, Sug Woo

Galois representations arising from some compact Shimura varieties. (English) Zbl 1269.11053

Ann. Math. (2) 173, No. 3, 1645-1741 (2011).

The article under review establishes new, very deep and very important existence results for Galois representations attached to automorphic forms, as predicted by the Langlands philosophy. The main theorem is the following:

Let F be a CM field and let Π be a regular algebraic conjugate self-dual cuspidal automorphic representation of $\mathrm{GL}_m(\mathbb{A}_F)$ for some integer $m \geq 2$. If m is even, then assume in addition a condition called 'slight regularity' (referred to as 'Shin regularity' in later work by other authors). Then for any prime number ℓ and for any choice of isomorphism $\iota_\ell : \overline{\mathbb{Q}}_\ell \to \mathbb{C}$ there exists a continuous semisimple Galois representation

$$R_{\ell,\iota_\ell}(\Pi) : \mathrm{Gal}(\overline{F}/F) \to \mathrm{GL}_m(\overline{\mathbb{Q}}_\ell)$$

satisfying a long list of properties, including the following ones: the representation Π corresponds to $R_{\ell,\iota_\ell}(\Pi)$ under the local Langlands correspondence at all finite places of F not dividing ℓ, that is, 'local-global compatibility' is fulfilled. If λ is a finite place of F above ℓ, then the Galois representation $R_{\ell,\iota_\ell}(\Pi)$ is potentially semistable at λ with distinct and explicit Hodge-Tate weights. If, moreover, Π is unramified at λ, then $R_{\ell,\iota_\ell}(\Pi)$ is crystalline at λ.

In fact, the author obtains the stronger result that the $R_{\ell,\iota_\ell}(\Pi)$ form a compatible system of Galois representations. A corollary of the main result is the Ramanujan-Petersson conjecture for Π, that is, Π is tempered at all finite places of F. A result similar to the main theorem can be proved, when F is a totally real field, by adapting a technique applied by *R. Taylor* in [Ann. Fac. Sci. Toulouse, VI. Sér., Math. 13, No. 1, 73–119 (2004; Zbl 1074.11030)] (see Remark 7.6 of the present article).

The main theorem of the article under review strengthens previous results by *R. E. Kottwitz* [Invent. Math. 108, No. 3, 653–665 (1992; Zbl 0765.22011)], *L. Clozel* [Publ. Math., Inst. Hautes Étud. Sci. 73, 97–145 (1991; Zbl 0739.11020)], *M. Harris* and *R. Taylor* [The geometry and cohomology of some simple Shimura varieties. Princeton, NJ: Princeton University Press (2001; Zbl 1036.11027)], and *R. Taylor* and *T. Yoshida* [J. Am. Math. Soc. 20, No. 2, 467–493 (2007; Zbl 1210.11118)], which need the extra assumption that Π is square integrable at some finite place. However, in that case the irreducibility of $R_{\ell,\iota_\ell}(\Pi)$ is known (it is not established in the article under review).

Results similar to the main result were proved by *S. Morel* [On the cohomology of certain noncompact Shimura varieties. With an appendix by Robert Kottwitz. Princeton, NJ: Princeton University Press (2010; Zbl 1233.11069)] and *L. Clozel, M. Harris* and *J.-P. Labesse* ["Construction of automorphic Galois representations. I", in: Stabilization of the trace formula, Shimura varieties, and arithmetic applications. Volume 1: On the stabilization of the trace formula. Somerville, MA: International Press, 497–523 (2011; Zbl 1255.11027)], however, without establishing local-global compatibility at ramified primes away from ℓ.

G. Chenevier and *M. Harris* ["Construction of automorphic Galois representations. II", Camb. Math. J. 1, 53–73 (2013)] managed to remove the 'slight regularity' assumption (in the case of even m) by an ℓ-adic deformation argument, however, at the expense of having local-global compatibility only up to semisimplification at primes not above ℓ.

The strategy of the proof of the main result of the article, which is technically very demanding, is summarized in quite some detail in the introduction. In this review we content ourselves with some generalities: The conditions on Π imply that it gives rise to an automorphic representation of some unitary group, and $R_{\ell,\iota_\ell}(\Pi)$ is hence realized in the ℓ-adic cohomology of certain Shimura varieties of unitary type. The extra condition in the case of even m comes from the fact that then the Galois representation lies in the endoscopic part of the cohomology. The computation of the cohomology of the Shimura variety is through the use of certain Igusa varieties and builds on the work of Harris-Taylor cited above and *E. Mantovan* (e.g. [Fields Institute Communications 60, 61–83 (2011; Zbl 1258.11069)]). The computation of the relevant part of the cohomology of the Igusa variety is at the center of the present article and relies on earlier work of the author [Duke Math. J. 146, No. 3, 509–568 (2009; Zbl 1218.11061)] and [J. Inst. Math. Jussieu 9, No. 4, 847–895 (2010; Zbl 1206.22011)]. Let us finally point out that the fundamental

lemma proved by *B. C. Ngô* enters the proof essentially [Publ. Math., Inst. Hautes Étud. Sci. 111, 1–271 (2010; Zbl 1200.22011)].

Reviewer: Gabor Wiese (Luxembourg)

MSC:

11F80	Galois representations
11G18	Arithmetic aspects of modular and Shimura varieties
11F03	Modular and automorphic functions
14G35	Modular and Shimura varieties

Keywords:

automorphic representations; endoscopy; Galois representations; Igusa varieties; Langlands correspondence; Shimura varieties; trace formula; fundamental lemma

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