

## CHARACTER VARIETY OF REPRESENTATIONS OF A FINITELY GENERATED GROUP IN $SL_2$

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This is a partial exposition of [S4, S5, S6], which study the space of representations of a (finitely generated) group  $\Gamma$  in  $SL_2$  and  $GL_2$  in an attempt of its application in geometry: Teichmüller spaces, knot theory, hyperbolic manifolds, moduli spaces,  $\dots$ , etc. (see for instance, [A], [Be], [Br], [C-C-G-L-S], [C-S], [F-K], [G], [H], [H-L-M], [H-K], [J-W], [K], [Kj], [Ko], [Kr], [Ma], [Mu], [N-Z], [O], [S], [S-S], [T], [W], [We], [Wo], [Y],  $\dots$ , etc). For simplicity, we omit the case for  $GL_2$  in the present exposition. Let us explain the main result of the present paper.

Let  $\Gamma$  be a group. The purpose of the present paper is to introduce the character variety  $\text{Ch}(\Gamma, SL_2)$  in order to parameterize conjugacy classes of representations of  $\Gamma$  in  $SL_2$  in a functorial way. At first, the character variety is introduced as a scheme over  $\mathbb{Z}$ , independent of the coefficient ring of representations in question. Then, the scalar field is specialized to  $\mathbb{R}$  to obtain results on representations in  $SL_2(\mathbb{R})$  and in  $SU(2)$  with respect to the classical topology. Let us explain this briefly.

Let  $\text{Hom}(\Gamma, SL_n)$  be the functor  $R \in \{\text{commutative rings with } 1\} \mapsto \text{Hom}(\Gamma, SL_n(R)) \in \{\text{sets}\}$ . The functor is representable (see §1.3 Lemma) and so, for an abuse of notation, we denote by the same  $\text{Hom}(\Gamma, SL_n)$  the scheme over  $\mathbb{Z}$  representing the functor. The group scheme  $\text{PGL}_n$  acts on  $\text{Hom}(\Gamma, SL_n)$ . Whether the universal categorical quotient  $\text{Hom}(\Gamma, SL_n) // \text{PGL}_n$  (Mumford [Mu1]) defined over  $\mathbb{Z}$  exists or not seems to be a hard and unsolved question. Instead of asking directly for the quotient space, we introduce *i)* the *character variety*  $\text{Ch}(\Gamma, SL_2)$  together with its *discriminant subvariety*  $D_\Gamma$  as schemes over  $\mathbb{Z}$  abstractly, and *ii)* the  $\text{PGL}_2$ -invariant morphism  $\pi_\Gamma: \text{Hom}(\Gamma, SL_2) \rightarrow \text{Ch}(\Gamma, SL_2)$ , for which we prove that *i)* the restriction of  $\pi_\Gamma$  on the complement of  $\pi_\Gamma^{-1}(D_\Gamma)$  is a principal  $\text{PGL}_2$ -bundle with respect to the *étal* topology, and *ii)* the inverse image  $\pi_\Gamma^{-1}(D_\Gamma)$  is a subfunctor of  $\text{Hom}(\Gamma, SL_2)$  consisting of abelian or reducible representations. This implies that the complement  $\text{Hom}^*(\Gamma, SL_2) := \text{Hom}(\Gamma, SL_2) \setminus \pi_\Gamma^{-1}(D_\Gamma)$  consists of absolutely irreducible representations, and that  $\text{Hom}^*(\Gamma, SL_2)$  has the universal categorical quotient space  $\text{Ch}^*(\Gamma, SL_2) := \text{Ch}(\Gamma, SL_2) \setminus D_\Gamma$  defined over  $\mathbb{Z}$ . Then the result is specialized

# Sl2 Representations Of Finitely Presented Groups

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