

An arithmetic Riemann–Roch theorem

Henri Gillet^{1,*} and Christophe Soulé²

¹ Department of Mathematics, University of Illinois at Chicago, Box 4348, Chicago IL 60680, USA

² I.H.E.S., and C.N.R.S. Mathématiques, 35, route de Chartres, F-91440 Bures-Sur-Yvette, France

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Introduction

We prove in this paper an arithmetic analog of the Riemann–Roch–Grothendieck theorem for the determinant of the cohomology of an Hermitian vector bundle of arbitrary rank on a family of arithmetic varieties of arbitrary dimension. We also show that high powers of ample line bundles on arithmetic varieties have small sections.

Let X and Y be regular quasi-projective flat schemes over \mathbb{Z} . Consider an Hermitian vector bundle $\bar{E} = (E, h)$ on X : E is an algebraic vector bundle on X and h is an Hermitian metric on the associated holomorphic vector bundle on $X(\mathbb{C})$, which is invariant under complex conjugation. In [GS2] we defined arithmetic Chow groups $\widehat{CH}^p(X)$, $p \geq 0$, and in [GS3] we attached to (E, h) arithmetic characteristic classes such as the Chern character $\widehat{ch}(E, h) \in \widehat{CH}^*(X)_{\mathbb{Q}} = \bigoplus_{p \geq 0} \widehat{CH}^p(X) \otimes_{\mathbb{Z}} \mathbb{Q}$, and the Todd class $\widehat{Td}(E, h)$. Assume now that $f: X \rightarrow Y$ is a smooth projective morphism from X to Y . The determinant of cohomology $\lambda(E) = \det Rf_*(E)$ is an algebraic (graded) line bundle on Y . Choose an Hermitian metric h_f , invariant by conjugation, on the relative tangent space Tf , whose restriction to each fiber of f over $Y(\mathbb{C})$ is Kähler. The line bundle $\lambda(E)$ can then be equipped with the Quillen metric h_Q ([Q2], [BGS1] or 4.1.1 below).

Our main result (Theorem 7) computes the first arithmetic Chern class of $(\lambda(E), h_Q)$ in the \mathbb{Q} -vector space $\widehat{CH}^1(Y) \otimes_{\mathbb{Z}} \mathbb{Q}$. It reads

$$(1) \quad \hat{c}_1(\lambda(E), h_Q) = f_* (\widehat{ch}(E, h) \widehat{Td}(Tf, h_f) - \alpha(\widehat{ch}(E_{\mathbb{C}}) Td(Tf_{\mathbb{C}}) R(Tf_{\mathbb{C}})))^{(1)}.$$

Here $\alpha^{(1)}$ is the component of degree one of $\alpha \in \widehat{CH}^*(Y)_{\mathbb{Q}}$, α is the map from the real cohomology of $Y(\mathbb{C})$ to $\widehat{CH}^*(Y)_{\mathbb{Q}}$ defined in [GS2, 3.3.4] and in 2.2.1 below, and R is the additive characteristic class (in real cohomology) attached to the power series

$$R(x) = \sum_{\substack{m \text{ odd} \\ m \geq 1}} \left(2\zeta'(-m) + \left(1 + \frac{1}{2} + \dots + \frac{1}{m} \right) \zeta(-m) \right) \frac{x^m}{m!}$$

* Supported by a grant from the NSF

Arithmetic Riemann Roch Theorem For Singular Arithmetic Surfaces

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