

**Zeitschrift:** L'Enseignement Mathématique  
**Herausgeber:** Commission Internationale de l'Enseignement Mathématique  
**Band:** 39 (1993)  
**Heft:** 1-2: L'ENSEIGNEMENT MATHÉMATIQUE

**Artikel:** JACOBI FORMS AND SIEGEL MODULAR FORMS: RECENT RESULTS AND PROBLEMS  
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**Kapitel:** 1.1. Siegel modular forms of genus 2  
**DOI:** <https://doi.org/10.5169/seals-60416>

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## JACOBI FORMS AND SIEGEL MODULAR FORMS: RECENT RESULTS AND PROBLEMS

by Winfried KOHNEN

### INTRODUCTION

In the present paper we would like to describe some recent developments how Jacobi forms can be used to study Siegel modular forms of genus 2 and what problems arise in this way. After a preliminary section on Siegel modular forms and Jacobi forms (§ 1) which mainly serves to fix some notation, we shall discuss the so called Maass space in § 2. We shall then study relations between Jacobi forms and spinor zeta functions of Hecke eigenforms of genus 2 (§ 3) and finally in § 4 will indicate how Jacobi forms can be used to give estimates for Fourier coefficients of Siegel cusp forms.

Sections 2-4 are divided into two parts: part one describes known results while part two gives some open problems.

We do not go here into any more intrinsic properties of Jacobi forms (as e.g. the trace formula or relations to modular forms of integral weight) nor discuss any representation-theoretic aspects of the theory. For good surveys, we refer to [33, 36] for the first and to [3] for the second topic.

### § 1. PRELIMINARIES ON SIEGEL MODULAR FORMS AND JACOBI FORMS

#### 1.1. SIEGEL MODULAR FORMS OF GENUS 2

We write  $\mathcal{H}_2$  for the Siegel upper half-space of genus 2. The natural action of  $\mathrm{Sp}_2(\mathbf{R})$  on  $\mathcal{H}_2$  is denoted by

$$(M, Z) \mapsto M \langle Z \rangle := (AZ + B)(CZ + D)^{-1}$$

$$\left( M = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \in \mathrm{Sp}_2(\mathbf{R}), \quad Z \in \mathcal{H}_2 \right).$$

We put  $\Gamma_2 := \mathrm{Sp}_2(\mathbf{Z})$  and for  $k \in \mathbf{Z}$  denote by  $M_k(\Gamma_2)$  the space of Siegel modular forms of weight  $k$  on  $\Gamma_2$ , i.e. the space of holomorphic func-

tions  $F: \mathcal{H}_2 \rightarrow \mathbf{C}$  satisfying  $F(M \langle Z \rangle) = \det(CZ + D)^k F(Z)$  for all  $M = \begin{pmatrix} \cdot & \cdot \\ C & D \end{pmatrix} \in \Gamma_2$ . Such a function has a Fourier expansion

$$F(Z) = \sum_{T = T' \geq 0} a(T) e^{2\pi i \operatorname{tr}(TZ)}$$

where  $T$  runs over all positive semi-definite half-integral  $(2, 2)$ -matrices. We write  $S_k(\Gamma_2)$  for the subspace of cusp forms (require  $a(T) = 0$  for  $T \not\geq 0$ ).

For  $F, G \in S_k(\Gamma_2)$  we denote by

$$\langle F, G \rangle = \int_{\Gamma_2 \backslash \mathcal{H}_2} F(Z) \overline{G(Z)} (\det Y)^{k-3} dX dY \quad (X = \operatorname{Re}(Z), Y = \operatorname{Im}(Z))$$

the Petersson scalar product of  $F$  and  $G$ .

For basic facts on Siegel modular forms we refer to [12, 17].

## 1.2. JACOBI FORMS

We write  $\mathcal{H}$  for the complex upper half-plane. We let  $H(\mathbf{R})$  be the Heisenberg group, i.e. the set of triples  $((\lambda, \mu), \kappa) \in \mathbf{R}^2 \times \mathbf{R}$  with group law  $((\lambda, \mu), \kappa) ((\lambda', \mu'), \kappa') = ((\lambda + \lambda', \mu + \mu'), \kappa + \kappa' + \lambda\mu' - \lambda'\mu)$ , and denote by  $G^J := SL_2(\mathbf{R}) \times H(\mathbf{R})$  the Jacobi group where  $SL_2(\mathbf{R})$  operates on  $H(\mathbf{R})$  from the right by  $((\lambda, \mu), \kappa)M = ((\lambda, \mu)M, \kappa)$ . The group  $G^J$  acts on  $\mathcal{H} \times \mathbf{C}$  by

$$\left( \begin{pmatrix} a & b \\ c & d \end{pmatrix}, ((\lambda, \mu), \kappa) \right) \circ (\tau, z) = \left( \frac{a\tau + b}{c\tau + d}, \frac{z + \lambda\tau + \mu}{c\tau + d} \right).$$

We set  $\Gamma_1 := SL_2(\mathbf{Z})$ ,  $\Gamma_1^J := \Gamma_1 \times H(\mathbf{Z})$  and for  $k \in \mathbf{Z}$  and  $m \in \mathbf{N}_0$  denote by  $J_{k,m}$  the space of Jacobi forms of weight  $k$  and index  $m$  on  $\Gamma_1^J$ , i.e. the space of holomorphic functions  $\phi: \mathcal{H} \times \mathbf{C} \rightarrow \mathbf{C}$  satisfying the transformation formula

$$\phi(\gamma \circ (\tau, z)) = (c\tau + d)^k \exp \left( 2\pi i m \left( \frac{c(z + \lambda\tau + \mu)^2}{c\tau + d} - \lambda^2\tau - 2\lambda z \right) \right) \phi(\tau, z)$$

for all  $\gamma = \left( \begin{pmatrix} a & b \\ c & d \end{pmatrix}, ((\lambda, \mu), \kappa) \right) \in \Gamma_1^J$  and having a Fourier expansion

$$\phi(\tau, z) = \sum_{n, r \in \mathbf{Z}, r^2 \leq 4mn} c(n, r) q^n \zeta^r$$

where  $q = e^{2\pi i \tau}$ ,  $\zeta = e^{2\pi i z}$ . We write  $J_{k,m}^{\text{cusp}}$  for the subspace of cusp forms (require  $c(n, r) = 0$  for  $r^2 = 4mn$ ). Note that the coefficients  $c(n, r)$  depend