

COMPOSITION SERIES FOR DEGENERATE PRINCIPAL SERIES OF $GL(n)$

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ABSTRACT. In this note we consider representations of the group $GL(n, F)$, where F is the field of real or complex numbers or, more generally, an arbitrary local field, in the space of equivariant line bundles over Grassmannians over the same field F . We study reducibility and composition series of such representations.

Similar results were obtained already in [HL90, A112, Zel80], but we give a short uniform proof in the general case, using the tools from [AGS15a]. We also indicate some applications to cosine transforms in integral geometry.

1. INTRODUCTION

Let F be a local field, *i.e.* either \mathbb{R} or \mathbb{C} or a finite extension of the field \mathbb{Q}_p of p -adic numbers for some prime p , or the field $\mathbb{F}_q((t))$ of Laurent series over a finite field. Let $G = G_n := GL(n, F)$ be the group of invertible matrices of size n with entries in F .

Then $C^\infty(G)$ is a $G \times G$ -module with left and right actions given by $L_g f(x) = f(g^{-1}x)$, $R_g f(x) = f(xg)$. Let $P \subset G$ be a Lie subgroup with modular function Δ_P and let χ be a character of P . The induced representation $I(P, \chi) := \text{Ind}_P^G(\chi)$ is the right G -action on the space

$$(1) \quad C^\infty(G, P, \chi) := \left\{ f \in C^\infty(G) \mid L_{p^{-1}} f = \chi(p) \Delta_P^{1/2}(p) f \text{ for all } p \in P \right\},$$

whose elements may also be regarded as smooth sections of a line bundle on G/P .

We are interested in the so-called maximal parabolic subgroups $P = P_{p_1, p_2}$, with $p_1 + p_2 = n$, consisting of matrices $x \in G_n$ of the form

$$(2) \quad x = \begin{bmatrix} x_{11} & x_{12} \\ 0 & x_{22} \end{bmatrix}; x_{ij} \in \text{Mat}_{p_i \times p_j}.$$

In this case G/P is the Grassmannian of p_1 -dimensional subspaces of F^n . The characters of P are of the form $\chi_1 \otimes \chi_2(x) = \chi_1(x_{11}) \chi_2(x_{22})$, where χ_i is a character of G_{p_i} . Following [BZ77] we write $\chi_1 \times \chi_2$ instead of $I(P, \chi_1 \otimes \chi_2)$.

It is well known that the representation $\chi_1 \times \chi_2$ is irreducible for most characters χ_1, χ_2 . We explicitly describe the exceptional characters for which $\chi_1 \times \chi_2$ is reducible, and show that the composition series are monotone in a certain sense. We also show that if F is non-archimedean, the length of $\chi_1 \times \chi_2$ is at most two, *i.e.* it has at most one non-trivial G -invariant subspace.

In 1.1 below we describe the main results precisely. In 1.2 below we give applications to integral geometry.

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