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# MULTIPLIERS WHICH ARE NOT COMPLETELY BOUNDED

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ABSTRACT. For an infinite compact Abelian group $G$ and $1 < p < 2$, it was shown in [9] that there exists a $L^p(G)$ multiplier which is not completely bounded. In this note, we show that in infinite every locally compact Abelian group $G$ there is a $L^p(G)$ multiplier which is not completely bounded.

## 1. Introduction

Let $G$ be a locally compact Abelian group and $\hat{G}$ be its dual. A bounded linear operator $T$ on $L^P(G), 1 \leq p < \infty$, is called a $L^p$-multiplier if $T$ commutes with translation operator $\tau_x$ for each $x \in G$. We will denote the space of all $L^p$-multipliers by $M_p(G)$. It is well known that $T \in M_p(G)$ corresponds to a symbol $m \in L^\infty(\hat{G})$ such that $\widehat{Tf} = m\hat{f}$ for all $f \in L^1(G) \cap L^2(G)$. Sometimes we prefer to work with symbol $m$ in place of $T$.

We now briefly recall the natural operator space structure on $L^p(X)$-spaces, where $X$ is a $\sigma$-finite measure space. For details see [9, Chapter 2].

A $C^*$-algebra has a canonical operator space structure. We consider this canonical operator space structure on $L^\infty(X)$. The operator space structure on $L^1(X)$ is inherited from the dual of $L^\infty(X)$. By [3], with this operator space structure we have $L^1(X)^* = L^\infty(X)$ complete isometrically. Now by [9] the couple $(L^\infty(X), L^1(X))$ is compatible for operator space interpolation. We consider $L^p(X) = (L^\infty(X), L^1(X))_{\frac{1}{p}}$ with the operator space structure as the interpolating operator space structure from [9].

If a $L^p$ multiplier $T$ is completely bounded in the above mentioned operator space structure of $L^p$, we call this a *cb*-multiplier on $L^p(G)$. We will denote the space of all *cb*-multipliers on $L^p(G)$ by $M_p^{cb}(G)$. Throughout this paper, we will assume $G$ to be infinite.

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We will be repeatedly using following important result of Pisier [9] which provides a characterization of completely bounded maps on $L^p(G), 1 \le p < \infty$.

PROPOSITION 1.1. [9] *Let $S_p$ be the space of Schatten $p$-class operators on $l_2(\mathbb{Z})$. A linear map $T : L^p(X) \to L^p(X)$ is completely bounded if and only if the mapping $T \otimes I_{S_p}$ is bounded on $L^p(X, S_p)$. Moreover,*

$$\|T\|_{cb} = \|T \otimes I_{S_p}\|_{L^p(X,S_p)\to L^p(X,S_p)}.$$

Using above result one can see that $M_p^{cb}(G) = M_p(G)$ for $p = 1$ or 2. A natural question arises what happens for $1 < p < 2$. It was shown in [9, Proposition 8.1.3] that for a compact Abelian group $G$ and for $1 < p < 2$, the inclusion $M_p^{cb}(G) \subsetneq M_p(G)$ is strict. The purpose of this note is to show that this inclusion is strict for any locally compact Abelian group.

In [9, Proposition 8.1.3], an explicit construction of $m \in M_p(\mathbb{T}) \setminus M_p^{cb}(\mathbb{T})$ is provided for circle group $\mathbb{T}$. We briefly describe the construction below. Let $1 < p < 2$ and $\Lambda = \{3^{2i} + 3^{2j+1} : i, j \in \mathbb{N}\}$. Then $\Lambda$ is a $\Lambda_{p'}$ set in the sense that for any $f \in L^2(\mathbb{T})$ whose Fourier transform is supported in $\Lambda$, we have $\|f\|_{p'} \le C_{p'}\|f\|_2$ for some constant $C_{p'}$ depending on $p'$. It is well known that for $S_p, p \ne 2$ the canonical basis $(e_{ij})$ is not an unconditional basis. Furthermore, it is shown (see [9, Lemma 8.1.5]) that for any $n \in \mathbb{N}$ there exist complex scalars $\{z_{ij} : i, j = 1, 2, \dots, n\}$ and an element $x = \sum_{i,j} x_{ij}e_{ij}$ in the unit ball of $S_p$, $p \ne 2$, such that $\|\sum_{i,j} z_{ij}x_{ij}e_{ij}\|_{S_p} = n^{|\frac{1}{2}-\frac{1}{p}|}$. Define $m$ on $\mathbb{Z}$ by

$$m(n) = \begin{cases} z_{ij} & \text{if } n = 3^{2i} + 3^{2j+1}, \\ 0 & \text{otherwise.} \end{cases}$$

Since $\Lambda$ is a $\Lambda_{p'}$ set, we have $m \in M_p(\mathbb{T})$. However, the choice of $(z_{ij})$ and from Proposition 1.1 it follows that $m \notin M_p^{cb}(\mathbb{T})$. Same conclusion can be drawn for compact Abelian group with the help of $\Lambda_p$ sets.

For non-compact locally compact Abelian group $G$, we will approach the problem of strict inclusion via suitable transference techniques. In order to explain this explicitly in the case of $G = \mathbb{R}$, we need following terminology.

DEFINITION 1.2. Let $\phi_n(x) = \frac{1}{2n}\chi_{[-n,n]} * \chi_{[-n,n]}(x)$. A function $m \in L^\infty(\mathbb{R})$ is said to be normalized (with respect to $\{\phi_n\}$) if $\lim_{n\to\infty}(\hat{\phi}_n * m)(x) = m(x)$ for all $x \in \mathbb{R}$.

In particular, a bounded continuous function is always normalized. Our main result in this note is the following theorem, which is *cb* version of deLeeuw's theorem [5].

THEOREM 1.3. *Let $m$ be normalized and $m \in M_p^{cb}(\mathbb{R})$. Then $m|_{\mathbb{Z}} \in M_p^{cb}(\mathbb{T})$ with $\|T_{m|_{\mathbb{Z}}}\|_{cb} \le \|T_m\|_{cb}$.*

Theorem 1.3 provides an explicit construction of $\tilde{m} \in M_p(\mathbb{R}) \setminus M_p^{cb}(\mathbb{R})$. Consider the multiplier $m \in M_p(\mathbb{T}) \setminus M_p^{cb}(\mathbb{T})$ described above. We extend $m$

to $\mathbb{R}$ as a piece-wise linear continuous function $\tilde{m}$. Since $\tilde{m}$ is bounded and continuous it is normalized with respect to $\{\phi_n\}$ (as in Definition 1.2) and $\tilde{m} \in M_p(\mathbb{R})$ (see [8]). If $\tilde{m} \in M_p^{cb}(\mathbb{R})$, then by Theorem 1.3 we have $m \in M_p^{cb}(\mathbb{T})$. This contradicts the construction of $m$ and hence $\tilde{m} \in M_p(\mathbb{R}) \setminus M_p^{cb}(\mathbb{R})$.

In Section 2 we prove Theorem 1.3 and in Section 3 we will show strict inclusion $M_p^{cb}(G) \subsetneq M_p(G)$ for arbitrary non-compact locally compact Abelian group.

## 2. Transference of *cb* multipliers

Our main tool in this paper is a transference result (Theorem 2.1) for *cb*-multipliers. This is a *cb* version of transference couple result by Berkson, Paluszynki and Weiss [2]. Techniques adopted to prove our result is along the same line as in [2] with appropriate use of Proposition 1.1.

Theorem 2.1. *Let $G$ be an amenable group and $X$ a $\sigma$-finite measure space. Let $R, S : G \to \mathcal{CB}(L^p(X))$ satisfy the following conditions*:

(i) *for each $f \in L^p(X), u \mapsto R_u f$ and $u \mapsto S_u f$ are strongly continuous maps.*
(ii) *$C_R = \sup_{u\in G} \|R_u\|_{cb} < \infty$ and $C_S = \sup_{u\in G} \|S_u\|_{cb} < \infty$.*
(iii) *$S_u R_v = R_{uv}$ and $S_u S_v = S_{uv}$ for all $u, v \in G$.*

*Let $k \in L^1(G)$ have compact support. Consider the operator $H_k$ on $L^p(X)$ defined by*

$$H_k f(\cdot) = \int_G k(u) R_{u^{-1}} f \, du(\cdot).$$

*If $N_p(k)$ denotes the cb-norm of the convolution operator $F \mapsto k * F$ on $L^p(G)$, then we have $H_k$ is a cb map on $L^p(X)$ and $\|H_k\|_{cb} \le C_S C_R N_p(k)$.*

*Proof.* In view of Proposition 1.1 in order to show that $H_k$ is a *cb* map on $L^P(X)$, we need to show $H_k \otimes I$ is a bounded map on $L^p(S_p)$ where $I$ is the identity map on $S_p$.

It is easy to see that $(S_{v^{-1}} \otimes I)(S_v \otimes I)(H_k \otimes I) = H_k \otimes I$ on $L^p(G) \otimes S_p$. For $l \in \mathbb{N}$, $\{f_n\}_{n=1}^l \subseteq C_c(X)$ and $\{h_n\}_{n=1}^l \subseteq S_p$ we have

$$(S_v \otimes I)(H_k \otimes I)\left(\sum_n f_n \otimes h_n(x)\right) = \sum_n \int_G k(u) R_{vu^{-1}} f_n(\cdot) \, du \otimes h_n(x).$$

Hence,

$$\begin{aligned} &\left\|(H_k \otimes I)\left(\sum_n f_n \otimes h_n\right)\right\|_{L^p(S_p)}^p \\ &\quad \le C_s^p \left\|\sum_n \int_G k(u) R_{vu^{-1}} f_n(\cdot) \, du \otimes h_n\right\|_{L^p(S_p)}^p \qquad \text{(by Proposition 1.1)} \\ &\quad = C_s^p \int_X \left\|\sum_n \int_G k(u) R_{vu^{-1}} f_n(\cdot) \, du \otimes h_n(x)\right\|_{S_p}^p dx. \end{aligned}$$

The above inequality is true for all $v \in G$. For a suitable neighborhood $V$ of identity in $G$, which we will choose later, we have,

$$\begin{aligned}
&\left\|(H_k \otimes I)\left(\sum_n f_n \otimes h_n\right)\right\|^p_{L^p(S_p)} \\
&\quad \le C_s^p \frac{1}{|V|} \int_X \int_V \left\|\sum_n \int_G k(u) R_{vu^{-1}} f_n(\cdot)\, du \otimes h_n(x)\right\|^p_{S_p} dv\, dx \\
&\quad \le C_s^p \frac{1}{|V|} \int_X \int_G \left\|\sum_n \int_G k(u) R_{vu^{-1}} f_n(x)\, du h_n\right\|^p_{S_p} dv\, dx \\
&\quad \le C_s^p \frac{1}{|V|} \int_X \int_G \left\|\sum_n \big(k * F_n(\cdot, x) \otimes h_n\big)(v)\right\|^p_{S_p} dv\, dx,
\end{aligned}$$

where $F_n(v,x) = \chi_{VK^{-1}}(v) R_v f_n(x)$ and $K$ is the support of $k$. Observe that $F_n(\cdot, x) \in L^p(G)$ for a.e. $x$. Hence,

$$\begin{aligned}
&\left\|(H_k \otimes I)\left(\sum_n f_n \otimes h_n\right)\right\|^p_{L^p(S_p)} \\
&\quad \le C_s^p \frac{1}{|V|} \int_X N_p(k)^p \int_G \left\|\sum_n \big(F_n(\cdot, x) \otimes h_n\big)(v)\right\|^p_{S_p} dv\, dx \\
&\quad = C_s^p \frac{1}{|V|} N_p(k)^p \int_G \int_X \left\|\sum_n F_n(v,x) h_n\right\|^p_{S_p} dx\, dv \\
&\quad = C_s^p \frac{1}{|V|} N_p(k)^p \int_G \int_X \left\|\sum_n \chi_{VK^{-1}}(v) R_v f_n(x) h_n\right\|^p_{S_p} dx\, dv \\
&\quad = C_s^p \frac{1}{|V|} N_p(k)^p \int_G \chi_{VK^{-1}}(v) \int_X \left\|\sum_n R_v f_n(x) h_n\right\|^p_{S_p} dx\, dv \\
&\quad = C_s^p \frac{1}{|V|} N_p(k)^p \int_G \chi_{VK^{-1}}(v) \left\|(R_v \otimes I) \sum_n f_n \otimes h_n\right\|^p_{L^p(S_p)} dv \\
&\quad \le C_s^p C_R^p \frac{1}{|V|} N_p(k)^p |VK^{-1}| \left\|\sum_n f_n \otimes h_n\right\|^p_{L^p(S_p)}.
\end{aligned}$$

Last inequality follows from Proposition 1.1. Since $G$ is amenable, for every $\varepsilon > 0$ and compact set $K$ we can choose a neighborhood $V$ of identity such that $\frac{|VK^{-1}|}{|V|} < 1 + \varepsilon$. Hence, $\|(H_k \otimes I)(\sum_n f_n \otimes h_n)\|_{L^p(S_p)} \le C_s C_R N_p(k) \|\sum_n f_n \otimes h_n\|_{L^p(S_p)}$. ∎

We will need following lemmas to prove Theorem 1.3. These results are analogue of usual $L^p$ multipliers and can be of independent interest.

LEMMA 2.2. *Let* $N \in \mathbb{N}$. *If*

$$\left|\int_{\hat{G}}\left(\sum_{n=1}^{N}\hat{f}'_n(\xi)h'_n\right)\left(\sum_{n=1}^{N}m(\xi)\hat{f}_n(\xi)h_n\right)d\xi\right| \\ \leq c_m\left\|\sum_{n=1}^{N}f_n\otimes h_n\right\|_{L^p(S_p)}\left\|\sum_{n=1}^{N}f'_n\otimes h'_n\right\|_{L^{p'}(S_{p'})}$$

*for all* $f_n, f'_n \in C_c(G)$ *and for all* $h_n \in S_p, h'_n \in S_{p'}, n = 1, 2, \ldots, N,$ *where* $c_m$ *is a constant which does not depend on* $N$ *then* $m \in M_p^{cb}(G)$.

*Proof.* The result follows from the density of the elements $\sum_{n=1}^{N} f_n \otimes h_n, N \in \mathbb{N}, f_n \in C_c(G), h_n \in S_p$ in $L^p(S_p)$ and duality of $L^p(S_p)$ and $L^{p'}(S_{p'})$. ☐

LEMMA 2.3. *If* $m \in M_p^{cb}(G)$ *the* $\tau_y m \in M_p^{cb}(G)$ *and* $\|T_{\tau_y m}\|_{cb} = \|T_m\|_{cb}$.

*Proof.* Observe that

$$\left\|\sum_n e^{iy\cdot}f_n\otimes h_n\right\|^p_{L^p(S_p)} = \left\|\left(\sum_n f_n\otimes h_n\right)\right\|_{L^p(S_p)}$$

Hence,

$$\left|\int_{\hat{G}}\left\langle\sum_n m(\xi-y)\hat{f}_n(\xi)h_n, \sum_n \hat{f}'_n(\xi)h'_n\right\rangle d\xi\right| \\ = \left|\int_{\hat{G}}\left\langle\sum_n m(\xi)\widehat{e^{iy\cdot}f_n}(\xi)h_n, \sum_n \widehat{e^{iy\cdot}f'_n}(\xi)h'_n\right\rangle d\xi\right| \\ \leq \|T_m\|_{cb}\left\|\sum_n e^{iy\cdot}f_n\otimes h_n\right\|^p_{L^p(S_p)}\left\|\sum_n e^{iy\cdot}f'_n\otimes h'_n\right\|_{L^{p'}(S_{p'})} \\ \leq \|T_m\|_{cb}\left\|\sum_n f_n\otimes h_n\right\|^p_{L^p(S_p)}\left\|\sum_n f'_n\otimes h'_n\right\|_{L^{p'}(S_{p'})}.$$

Hence by Lemma 2.2, we have $\|T_{\tau_y m}\|_{cb} = \|T_m\|_{cb}$. ☐

LEMMA 2.4. *Let* $k \in L^1(\hat{G})$ *and* $m \in M_p^{cb}(G)$ *then* $k * m \in M_p^{cb}(G)$ *with* $\|T_{k*m}\|_{cb} \leq \|k\|_1\|T_m\|_{cb}$.

*Proof.* We will use Lemma 2.2 to conclude that $k * m \in M_p^{cb}(G)$. Now for any finite sum we have

$$\left|\int_{\hat{G}}\left\langle\sum_n k*m(\xi)\hat{f}_n(\xi)h_n, \sum_n \hat{f}'_n(\xi)h'_n\right\rangle d\xi\right| \\ = \left|\int_{\hat{G}}\int_{\hat{G}}k(\eta)\left\langle\sum_n m(\xi-\eta)\hat{f}_n(\xi)h_n, \sum_n \hat{f}'_n(\xi)h'_n\right\rangle d\eta\, d\xi\right|$$

$$\leq \|k\|_1 \|T_m\|_{cb} \left\| \sum_n f_n \otimes h_n \right\|_{L^p(S_p)} \left\| \sum_n f'_n \otimes h'_n \right\|_{L^{p'}(S_{p'})}.$$

The last inequality follows from Lemma 2.3. □

Proof of the following result follows from dominated convergence theorem and Lemma 2.2.

LEMMA 2.5. *Let* $\{m_n\} \subset M_p^{cb}(G)$ *such that* $\lim_n m_n(x) = m(x)$ *a.e. If* $\|T_{m_n}\|_{cb} \leq C < \infty$ *then* $m \in M_p^{cb}(G)$.

*Proof of Theorem* 1.3. We will first prove it for $m = \hat{k}$, where $k \in L^1(\mathbb{R})$, and has compact support.

Define $R : \mathbb{R} \to \mathcal{B}(L^p(\mathbb{T}))$ as $R_x f(u) = f(u - x)$, where $x - u$ is interpreted as sum modulo 1. Taking $S = R$, the pair $(R, S)$ satisfies all the hypotheses of Theorem 2.1. Hence, the operator $H_k$ defined in Theorem 2.1 is a *cb* map. Observe that for $f \in C(\mathbb{T})$,

$$\begin{aligned}\widehat{H_k f}(n) &= \int_{\mathbb{R}} k(x) \widehat{R_{-x} f}(n)\, dx \\ &= \int_{\mathbb{R}} k(x) e^{-2\pi i x n} \hat{f}(n)\, dx \\ &= m|_{\mathbb{Z}}(n) \hat{f}(n).\end{aligned}$$

We now prove the result for a general normalized multiplier $m$. Let $\{\phi_n\}$ be as in Definition 1.2. Let $m_n(x) = \hat{\phi}_n * m(x)$. By Lemma 2.4 we have $m_n \in M_p^{cb}(\mathbb{R})$. Also, $\lim_n m_n(x) = m(x)$ $\forall x \in \mathbb{R}$. As $\|\hat{\phi}_n\|_1 = 1$ we have $\|T_{m_n}\|_{cb} \leq \|T_m\|_{cb}$.

Let $\psi \in L^2(\mathbb{R})$ with $\psi \geq 0$ with compact support and $\int_{\mathbb{R}} \psi(x)\, dx = 1$. We define $h_n(x) = n\psi(nx)$. Clearly $\hat{h}_n(x) = \hat{\psi}(x/n) \to 1$ as $n \to \infty$. Consider the sequence $\tilde{k}_n = (m_n \hat{h}_n)^{\vee}$. Since $m_n \hat{h}_n \in L^2(\mathbb{R})$ and their Fourier transform has compact support we conclude $\tilde{k}_n \in L^1(\mathbb{R})$ with compact support. Hence, from our earlier observation $\hat{\tilde{k}}_n|_{\mathbb{Z}} \in M_p^{cb}(\mathbb{T})$ with uniform *cb* norm. Now $\hat{\tilde{k}}_n(x) \to m(x), \forall x \in \mathbb{R}$ as $n \to \infty$. Finally, by Lemma 2.5 we have $m|_Z \in M_p^{cb}(\mathbb{T})$. □

## 3. *cb* homomorphism theorem for locally compact Abelian group

In this section, we address the problem of strict inclusion $M_p^{cb}(G) \subsetneq M_p(G)$ for non-compact locally compact Abelian group $G$. We will achieve this by transferring the known result on compact Abelian group to this set up. As in Section 2 the main ingredient here is the following *cb* version of multiplier homomorphism theorem [6], [1].

THEOREM 3.1. *Let $G_1$ and $G_2$ be two locally compact Abelian groups. Suppose $m \in M_p^{cb}(G_1)$ and is continuous. If $\pi : \hat{G}_2 \to \hat{G}_1$ be a continuous homomorphism, then $m \circ \pi \in M_p^{cb}(G_2)$. Moreover,*

$$\|m \circ \pi\|_{cb} \leq \|m|_{cb}.$$

Suppose $\pi : \hat{G}_2 \to \hat{G}_1$ is a continuous homomorphism. Observe that such a $\pi$ will induce a continuous homomorphism $\hat{\pi}$ from $G_1$ to $G_2$ namely, $\hat{\pi}(x)(\gamma) = \pi(\gamma)(x)\ \forall x \in G_1, \gamma \in G_2$. Now for $f \in L^p(G_2)$ we define $R : G_1 \to \mathcal{B}(L^p(G_2))$ by $R_u f(x) = f(\hat{\pi}(u)x)$. Taking $R = S$ the pair $(R, S)$ satisfies the conditions of Theorem 2.1. Arguing exactly in the same fashion as in Theorem 1.3 we have Theorem 3.1 if $m = \hat{k}$ for some $k \in L^1(G_1)$ having compact support. We can get the result for general $m$ if there exists an approximate identity $\{\phi_i\}$ in $L^1(G_1)$ satisfying following conditions:

(1) $\phi_i \geq 0$ and $\int_{G_1} \phi_i(x)\, dx = 1\ \forall i \in I$.
(2) $\hat{\phi}_i \in C_c(\hat{G}_1)\ \forall i \in I$.
(3) $\lim_i \hat{\phi}_i(\gamma) = 1$ and the convergence is uniform on all compact subsets of $\hat{G}_1$.

Existence of such an approximate identity $\{\phi_i\}$ is guaranteed in [7, Theorem 33.12].

Now we consider our problem of constructing an $L^p(G)$ multiplier which is not a *cb* multiplier. Consider a discrete subgroup $K$ of $\hat{G}$. Then $H = \hat{K}$ is compact Abelian. Therefore, we can get a $L^p(H)$ multiplier $\phi$ which is not *cb*. By a construction of Cowling [4], we can extend $\phi$ continuously to a function $\psi \in M_p(G)$ such that $\psi|_K = \phi$. If $\psi \in M_p^{cb}(G)$, then by Theorem 3.1 we have $\phi \in M_p^{cb}(H)$ which is a contradiction. Hence, for every locally compact Abelian group $G$, the inclusion $M_p^{cb} \subsetneq M_p(G)$ is strict.

## References


[1] N. Asmar, E. Berkson and T. A. Gillespie, *Transference of strong maximal inequalities by separation preserving representation*, Amer. J. Math. **113** (1991), no. 1, 47–74. MR 1087801

[2] E. Berkson, M. Paluszyński and G. Weiss, *Transference couples and their applications to convolution operators and maximal operators*, Interaction between functional analysis, harmonic analysis, and probability (Columbia, MO, 1994), Lecture Notes in Pure and Appl. Math., vol. 175, Dekker, New York, 1996, 69–84. MR 1358144

[3] D. P. Blecher, *The standard dual of an operator space*, Pacific J. Math. **153** (1992), no. 1, 15–30. MR 1145913

[4] M. Cowling, *Extension of Fourier $L^p - L^q$ multipliers*, Trans. Amer. Math. Soc. **213** (1975), 1–33. MR 0390652

[5] K. deLeeuw, *On $L_p$ multipliers*, Ann. of Math. (2) **81** (1965) 364–379. MR 0174937

[6] R. E. Edwards and G. Gaudry, *Littlewood–Paley and multiplier theory*, Ergebnisse der Mathematik und ihrer Grenzgebiete, Band 90, Springer, Berlin, 1977. MR 0618663

[7] E. Hewitt and K. Ross, *Abstract harmonic analysis*, *Vol. II: Structure and analysis for compact groups. Analysis on locally compact Abelian groups*, Die Grundlehren der mathematischen Wissenschaften, Band 152, Springer, New York, 1970. MR 0262773

[8] M. Jodeit, *Restrictions and extensions of Fourier multipliers*, Studia Math. **34** (1970) 215–226. MR 0262771

[9] G. Pisier, *Non-commutative vector valued $L_p$-spaces and completely $p$-summing maps*, Astérisque, vol. 247, Math. Soc. France, 1998. MR 1648908

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