On centralizers of locally finite simple groups

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Semigroups and Groups, Automata, Logics

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Richard Brauer

Theorem

R. Brauer, K.A. Fowler – 1955

Let G be a finite group of even order n. Then G contains a proper subgroup of order strictly larger than $\sqrt[3]{n}$.

Corollary

R. Brauer, K.A. Fowler – 1955

There exist only a finite number of simple groups in which the centralizer of an involution is isomorphic to a given group.

Kargapolov, Hall-Kulatilaka (1963–1964) - Let G be an infinite locally finite group. Then G contains a non-trivial element whose centralizer is infinite.

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Šunkov (1965) - Let G be an infinite simple locally finite group. Then every involution of G has infinite centralizer.

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Let $\mathfrak{X}$ be a class of groups and let G be a locally finite group. What can be said about G if the centralizer of an $\mathfrak{X}$-subgroup is ”small”?

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Meierfrankenfeld (2007) - There exists a non-linear locally finite simple groups in which every involution has (locally soluble)-by-finite centralizer.

And many results on locally finite groups in which the centralizers of involutions satisfy some finiteness conditions

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Let G be a locally finite simple group. Has the centralizer of every finite p-subgroup infinite non-abelian rank?

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$$H_0 \times H_1 \times \cdots \times H_n \times \cdots \text{ where } H_0 \text{ is non-abelian.}$$

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Theorem

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Let G be any infinite simple locally finite group. Then either G is isomorphic to $\mathrm{PSL}(2, F)$, where F is an infinite locally finite field, or G contains a subgroup which is the direct product of an infinite abelian subgroup of prime exponent p and a finite non-abelian p-subgroup.

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In particular, any infinite simple locally finite group (with the exclusion of $\mathrm{PSL}(2, F)$, which has non-abelian rank at most 2) has infinite non-abelian rank and contains a finite non-abelian subgroup with an infinite centralizer.

Let F be an infinite locally finite field of characteristic 2 and $\theta \in \mathrm{Aut}F$ such that $f^{\theta^2} = f^2$ for each $f \in F$.

For any couple of elements α and β in F one defines

$$(\alpha, \beta) = \begin{pmatrix} 1 & 0 & 0 & 0 \\ \alpha & 1 & 0 & 0 \\ \alpha^{1+\theta} + \beta & \alpha^{\theta} & 1 & 0 \\ \alpha^{2+\theta} + \alpha\beta + \beta^{\theta} & \beta & \alpha & 1 \end{pmatrix}$$

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Notice that $(\alpha, \beta)(\gamma, \delta) = (\alpha + \gamma, \alpha\gamma^{\theta} + \beta + \delta)$.

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$\Rightarrow Sz(F) = \langle A, D, \tau \rangle$.

It is easy to see that A is a nilpotent non-abelian 2-subgroup of the group and that the subgroup H of A generated by all $(0, \beta)$ is the centre of A and is isomorphic with the additive group of F.

$$(0,\beta) = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \beta & 0 & 1 & 0 \\ \beta^{\theta} & \beta & 0 & 1 \end{pmatrix}$$

Remind that $(\alpha,\beta)(\gamma,\delta) = (\alpha+\gamma, \alpha\gamma^{\theta}+\beta+\delta)$.

It is easy to see that A is a nilpotent non-abelian 2-subgroup of the group and that the subgroup H of A generated by all $(0, \beta)$ is the centre of A and is isomorphic with the additive group of F. Hence, once taken two elements α and β in $F \setminus \{0\}$ such that $\alpha\beta^{\theta} \neq \alpha^{\theta}\beta$, we have that $\langle(\alpha, 0), (\beta, 0)\rangle H$ is decomposable into an infinite direct product of the requested type.

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6. a group of type $H \ltimes K$, where K is elementary abelian and H is cyclic acting fixed-point-freely on K;
7. $PSL(2, \mathbb{F}_{p^n})$ for any positive integer n dividing the Steinitz number of F.

Corollary

Let F be an infinite locally finite field. Then $\mathsf{PSL}(2, \mathsf{F})$ has non-abelian rank 2.

Main theorem rephrased

Let G be an infinite simple locally finite group. Then G is isomorphic to $\mathrm{PSL}(2, F)$ if and only if G has finite non-abelian rank. In this case, the rank of G is 2.

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M.B., Russo (2019) - Let G be a locally finite group satisfying the double chain condition on non-abelian subgroups. Then G cannot be simple.

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3. Do all locally finite simple groups (except for $PSL(2, F)$) contain a subgroup which is the direct product of an infinite abelian subgroup of infinite rank and a finite simple subgroup?

Thank you for your attention