A permutation group problem relating to groups acting on trees

Stephan Tornier



November 30, 2021

Problem

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group.

Problem

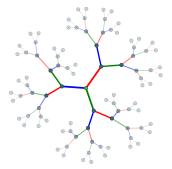
Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$.

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

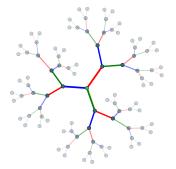
Problem

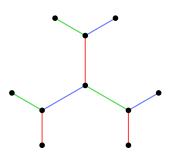
Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?



Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_\omega$ as follows: $g \cdot (g_\omega)_\omega := (gg_{g^{-1}\omega}g^{-1})_\omega$. What are all the G-invariant subgroups of K_G ?





 T_d

Generalised universal groups

$$\frac{g}{gx}$$

 T_d

 T_d

 $B_{d,k}$

gx

colour-preserving

Generalised universal groups

 T_d

$$\begin{array}{c}
g \\
\downarrow \\
colour-preserving \\
b \mapsto x
\end{array}$$

$$\begin{array}{c}
colour-preserving \\
gx \mapsto b
\end{array}$$

$$\begin{array}{c}
colour-preserving \\
gx \mapsto b
\end{array}$$

 $B_{d,k}$

 T_d

(ロ > 《圈 > 《돌 > 《돌 > · 돌 · 》 약 이 Q @

 $B_{d,k}$

$$\begin{array}{c}
g \\
\text{colour-preserving} \\
b \mapsto x \\
\text{b} \\
\hline
\\
\sigma_k(g,x) \\
\text{b}
\end{array}$$

Definition

 $B_{d,k}$

 T_d

For $F \leq \operatorname{Aut}(B_{d,k})$

 $B_{d,k}$

Definition

 $B_{d,k}$

 T_d

For $F \leq \operatorname{Aut}(B_{d,k})$, set $U_k(F) := \{g \in \operatorname{Aut}(T_d) \mid \forall x \in V(T_d) : \sigma_k(g,x) \in F\}$.

Definition

For $F \leq \operatorname{Aut}(B_{d,k})$, set $U_k(F) := \{g \in \operatorname{Aut}(T_d) \mid \forall x \in V(T_d) : \sigma_k(g,x) \in F\}$.

Definition

For
$$F \leq \operatorname{Aut}(B_{d,k})$$
, set $U_k(F) := \{g \in \operatorname{Aut}(T_d) \mid \forall x \in V(T_d) : \sigma_k(g,x) \in F\}$.

Theorem (T. '18)

$$\left\{ H \leq \operatorname{Aut}(T_d) \middle| \begin{array}{l} \textit{locally transitive} \\ \textit{inversion of order 2} \\ \textit{(P_k)-closed} \end{array} \right\} \stackrel{1:1}{\longleftrightarrow} \left\{ F \leq \operatorname{Aut}(B_{d,k}) \middle| \begin{array}{l} \textit{locally transitive} \\ \textit{Condition (C)} \end{array} \right\}$$

Definition

For
$$F \leq \operatorname{Aut}(B_{d,k})$$
, set $U_k(F) := \{g \in \operatorname{Aut}(T_d) \mid \forall x \in V(T_d) : \sigma_k(g,x) \in F\}$.

Theorem (T. '18)

$$\left\{ H \le \operatorname{Aut}(T_d) \middle| \begin{array}{l} \text{locally transitive} \\ \text{inversion of order 2} \\ (P_k)\text{-closed} \end{array} \right\} \xleftarrow{1:1} \left\{ F \le \operatorname{Aut}(B_{d,k}) \middle| \begin{array}{l} \text{locally transitive} \\ \text{Condition (C)} \end{array} \right\}$$

Proposition

Let $G \leq \operatorname{Sym}(\Omega)$.

Definition

For $F \leq \operatorname{Aut}(B_{d,k})$, set $U_k(F) := \{g \in \operatorname{Aut}(T_d) \mid \forall x \in V(T_d) : \sigma_k(g,x) \in F\}$.

Theorem (T. '18)

$$\left\{ H \leq \operatorname{Aut}(T_d) \middle| \begin{array}{l} \textit{locally transitive} \\ \textit{inversion of order 2} \\ \textit{(P_k)-closed} \end{array} \right\} \xleftarrow{1:1} \left\{ F \leq \operatorname{Aut}(B_{d,k}) \middle| \begin{array}{l} \textit{locally transitive} \\ \textit{Condition (C)} \end{array} \right\}$$

Proposition

Let $G \leq \operatorname{Sym}(\Omega)$. Every G-invariant subgroup $K \leq K_G$

Definition

For
$$F \leq \operatorname{Aut}(B_{d,k})$$
, set $U_k(F) := \{g \in \operatorname{Aut}(T_d) \mid \forall x \in V(T_d) : \sigma_k(g,x) \in F\}$.

Theorem (T. '18)

$$\left\{ H \le \operatorname{Aut}(T_d) \middle| \begin{array}{l} \text{locally transitive} \\ \text{inversion of order 2} \\ (P_k)\text{-closed} \end{array} \right\} \xleftarrow{1:1} \left\{ F \le \operatorname{Aut}(B_{d,k}) \middle| \begin{array}{l} \text{locally transitive} \\ \text{Condition (C)} \end{array} \right\}$$

Proposition

Let $G \leq \operatorname{Sym}(\Omega)$. Every G-invariant subgroup $K \leq K_G$ gives rise to a group $\Sigma(K) \leq \operatorname{Aut}(B_{d,2})$

Definition

For $F \leq \operatorname{Aut}(B_{d,k})$, set $U_k(F) := \{g \in \operatorname{Aut}(T_d) \mid \forall x \in V(T_d) : \sigma_k(g,x) \in F\}$.

Theorem (T. '18)

$$\left\{ H \leq \operatorname{Aut}(T_d) \middle| \begin{array}{l} \textit{locally transitive} \\ \textit{inversion of order 2} \\ \textit{(P_k)-closed} \end{array} \right\} \xleftarrow{1:1} \left\{ F \leq \operatorname{Aut}(B_{d,k}) \middle| \begin{array}{l} \textit{locally transitive} \\ \textit{Condition (C)} \end{array} \right\}$$

Proposition

Let $G \leq \operatorname{Sym}(\Omega)$. Every G-invariant subgroup $K \leq K_G$ gives rise to a group $\Sigma(K) \leq \operatorname{Aut}(B_{d,2})$ which satisfies Condition (C)

Definition

For $F \leq \operatorname{Aut}(B_{d,k})$, set $U_k(F) := \{g \in \operatorname{Aut}(T_d) \mid \forall x \in V(T_d) : \sigma_k(g,x) \in F\}$.

Theorem (T. '18)

$$\left\{ H \leq \operatorname{Aut}(T_d) \middle| \begin{array}{l} \textit{locally transitive} \\ \textit{inversion of order 2} \\ \textit{(P_k)-closed} \end{array} \right\} \stackrel{\text{1:1}}{\longleftrightarrow} \left\{ F \leq \operatorname{Aut}(B_{d,k}) \middle| \begin{array}{l} \textit{locally transitive} \\ \textit{Condition (C)} \end{array} \right\}$$

Proposition

Let $G \leq \operatorname{Sym}(\Omega)$. Every G-invariant subgroup $K \leq K_G$ gives rise to a group $\Sigma(K) \leq \operatorname{Aut}(B_{d,2})$ which satisfies Condition (C) and $\ker \pi|_{\Sigma(K)} = K$.

Definition

For $F \leq \operatorname{Aut}(B_{d,k})$, set $U_k(F) := \{g \in \operatorname{Aut}(T_d) | \forall x \in V(T_d) : \sigma_k(g,x) \in F\}$.

Theorem (T. '18)

$$\left\{ H \leq \operatorname{Aut}(T_d) \middle| \begin{array}{l} \textit{locally transitive} \\ \textit{inversion of order 2} \\ \textit{(P_k)-closed} \end{array} \right\} \xleftarrow{1:1} \left\{ F \leq \operatorname{Aut}(B_{d,k}) \middle| \begin{array}{l} \textit{locally transitive} \\ \textit{Condition (C)} \end{array} \right\}$$

Proposition

Let $G \leq \operatorname{Sym}(\Omega)$. Every G-invariant subgroup $K \leq K_G$ gives rise to a group $\Sigma(K) \leq \operatorname{Aut}(B_{d,2})$ which satisfies Condition (C) and $\ker \pi|_{\Sigma(K)} = K$.



Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Clearly, the trivial subgroup of K_G as well as K_G itself are G-invariant.

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Clearly, the trivial subgroup of K_G as well as K_G itself are G-invariant.

- $\bullet \ \Gamma := \{e\} \leq K_G,$
- \bullet $\Phi := K_G$.

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Clearly, the trivial subgroup of K_G as well as K_G itself are G-invariant.

- $\Gamma := \{e\} \le K_G$,
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$.

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Clearly, the trivial subgroup of K_G as well as K_G itself are G-invariant.

- $\Gamma := \{e\} \leq K_G,$
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$.

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Clearly, the trivial subgroup of K_G as well as K_G itself are G-invariant.

- $\Gamma := \{e\} \leq K_G,$
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Clearly, the trivial subgroup of K_G as well as K_G itself are G-invariant.

- $\Gamma := \{e\} \le K_G$,
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

•
$$\Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$$

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Clearly, the trivial subgroup of K_G as well as K_G itself are G-invariant.

- $\Gamma := \{e\} \le K_G$,
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

•
$$\Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$.

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Clearly, the trivial subgroup of K_G as well as K_G itself are G-invariant.

- $\Gamma := \{e\} \le K_G$,
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

•
$$\Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Clearly, the trivial subgroup of K_G as well as K_G itself are G-invariant.

- $\Gamma := \{e\} \leq K_G,$
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

•
$$\Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map such that $f_{\omega}(\omega_0) = \omega$ for all $\omega \in \Omega$.

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{g^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Clearly, the trivial subgroup of K_G as well as K_G itself are G-invariant.

- $\Gamma := \{e\} \leq K_G$,
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

•
$$\Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map such that $f_{\omega}(\omega_0) = \omega$ for all $\omega \in \Omega$. Define

Problem

Let Ω be a finite set and let $G \leq \operatorname{Sym}(\Omega)$ be a permutation group. Then G acts on $K_G := \prod_{\omega \in \Omega} G_{\omega}$ as follows: $g \cdot (g_{\omega})_{\omega} := (gg_{\sigma^{-1}\omega}g^{-1})_{\omega}$. What are all the G-invariant subgroups of K_G ?

Clearly, the trivial subgroup of K_G as well as K_G itself are G-invariant.

- $\Gamma := \{e\} < K_{G_1}$
- \bullet $\Phi := K_C$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigcup_{i \in I} \Omega_i$. Let $p:\Omega\to I$ be such that $\omega\in\Omega_{p(\omega)}$ for all $\omega\in\Omega$. Set

•
$$\Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f:\Omega\to G,\ f\mapsto f_\omega$ be a map such that $f_\omega(\omega_0)=\omega$ for all $\omega\in\Omega$. Define

•
$$\Phi_N := \{ (f_\omega s_0^{(\omega)} f_\omega^{-1})_{\omega \in \Omega} \mid \forall \omega \in \Omega : s_0^{(\omega)} \in N \} \cong N^d.$$

- $\Gamma := \{e\} \leq K_G$.
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

• $\Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map such that $f_{\omega}(\omega_0) = \omega$ for all $\omega \in \Omega$. Define

• $\Phi_{\mathcal{N}} := \{ (f_{\omega} s_0^{(\omega)} f_{\omega}^{-1})_{\omega \in \Omega} \mid \forall \omega \in \Omega : s_0^{(\omega)} \in \mathcal{N} \} \cong \mathcal{N}^d.$

- $\Gamma := \{e\} \leq K_G$.
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

$$\bullet \Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map such that $f_{\omega}(\omega_0) = \omega$ for all $\omega \in \Omega$. Define

$$\Phi_{\mathcal{N}} := \{ (f_{\omega} s_0^{(\omega)} f_{\omega}^{-1})_{\omega \in \Omega} \mid \forall \omega \in \Omega : s_0^{(\omega)} \in \mathcal{N} \} \cong \mathcal{N}^d.$$

When G is transitive and G_{ω_0} has non-trivial center,

- $\Gamma := \{e\} \le K_G$.
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

•
$$\Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map such that $f_{\omega}(\omega_0) = \omega$ for all $\omega \in \Omega$. Define

•
$$\Phi_N := \{ (f_\omega s_0^{(\omega)} f_\omega^{-1})_{\omega \in \Omega} \mid \forall \omega \in \Omega : s_0^{(\omega)} \in N \} \cong N^d.$$

When G is transitive and G_{ω_0} has non-trivial center, let $C \leq Z(G_{\omega_0})$.

- $\Gamma := \{e\} \leq K_G$.
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

• $\Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map such that $f_{\omega}(\omega_0) = \omega$ for all $\omega \in \Omega$. Define

• $\Phi_N := \{ (f_\omega s_0^{(\omega)} f_\omega^{-1})_{\omega \in \Omega} \mid \forall \omega \in \Omega : s_0^{(\omega)} \in N \} \cong N^d.$

When G is transitive and G_{ω_0} has non-trivial center, let $C \leq Z(G_{\omega_0})$. Set

- $\Gamma := \{e\} \leq K_G$.
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

 $\bullet \Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map such that $f_{\omega}(\omega_0) = \omega$ for all $\omega \in \Omega$. Define

• $\Phi_N := \{ (f_\omega s_0^{(\omega)} f_\omega^{-1})_{\omega \in \Omega} \mid \forall \omega \in \Omega : s_0^{(\omega)} \in N \} \cong N^d.$

When G is transitive and G_{ω_0} has non-trivial center, let $C \leq Z(G_{\omega_0})$. Set

- $\Gamma := \{e\} \leq K_G$.
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

$$\bullet \Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map such that $f_{\omega}(\omega_0) = \omega$ for all $\omega \in \Omega$. Define

•
$$\Phi_N := \{ (f_\omega s_0^{(\omega)} f_\omega^{-1})_{\omega \in \Omega} \mid \forall \omega \in \Omega : s_0^{(\omega)} \in N \} \cong N^d.$$

When G is transitive and G_{ω_0} has non-trivial center, let $C \leq Z(G_{\omega_0})$. Set

$$\bullet \ \Delta_C := \{ (f_\omega s_0 f_\omega^{-1})_{\omega \in \Omega} \mid s_0 \in C \} \cong C.$$

When G is not perfect,

- $\Gamma := \{e\} \leq K_G$.
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

•
$$\Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map such that $f_{\omega}(\omega_0) = \omega$ for all $\omega \in \Omega$. Define

•
$$\Phi_N := \{ (f_\omega s_0^{(\omega)} f_\omega^{-1})_{\omega \in \Omega} \mid \forall \omega \in \Omega : s_0^{(\omega)} \in N \} \cong N^d.$$

When G is transitive and G_{ω_0} has non-trivial center, let $C \leq Z(G_{\omega_0})$. Set

When *G* is not perfect, let $\rho : G \rightarrow A$, where *A* is abelian.

- $\Gamma := \{e\} \leq K_G$.
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

 $\bullet \Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map such that $f_{\omega}(\omega_0) = \omega$ for all $\omega \in \Omega$. Define

• $\Phi_N := \{ (f_\omega s_0^{(\omega)} f_\omega^{-1})_{\omega \in \Omega} \mid \forall \omega \in \Omega : s_0^{(\omega)} \in N \} \cong N^d.$

When G is transitive and G_{ω_0} has non-trivial center, let $C \leq Z(G_{\omega_0})$. Set

When G is not perfect, let $\rho : G \rightarrow A$, where A is abelian. Define

- $\Gamma := \{e\} \leq K_G$.
- \bullet $\Phi := K_G$.

Assume that G preserves a non-trivial partition $\mathcal{P}: \Omega = \bigsqcup_{i \in I} \Omega_i$. Let $p: \Omega \to I$ be such that $\omega \in \Omega_{p(\omega)}$ for all $\omega \in \Omega$. Set

$$\bullet \ \Phi_{\mathcal{P}} := \{ (s_{\omega})_{\omega} \in K_G \mid \forall \omega, \omega' \in \Omega : p(\omega) = p(\omega') \Rightarrow s_{\omega} = s_{\omega'} \} \cong \prod_{i \in I} G_{\Omega_i}$$

When G is transitive and the G_{ω} are not simple, let $N \subseteq G_{\omega_0}$. Also, let $f: \Omega \to G$, $f \mapsto f_{\omega}$ be a map such that $f_{\omega}(\omega_0) = \omega$ for all $\omega \in \Omega$. Define

•
$$\Phi_N := \{ (f_\omega s_0^{(\omega)} f_\omega^{-1})_{\omega \in \Omega} \mid \forall \omega \in \Omega : s_0^{(\omega)} \in N \} \cong N^d.$$

When G is transitive and G_{ω_0} has non-trivial center, let $C \leq Z(G_{\omega_0})$. Set

$$\bullet \ \Delta_C := \{ (f_\omega s_0 f_\omega^{-1})_{\omega \in \Omega} \mid s_0 \in C \} \cong C.$$

When G is not perfect, let $\rho : G \rightarrow A$, where A is abelian. Define

•
$$\Pi_{\rho} := \{ (s_{\omega})_{\omega} \in K_G \mid \prod_{\omega \in \Omega} \rho(s_{\omega}) = 1 \}.$$



Theorem

Let $G \leq \operatorname{Sym}(\Omega)$ be primitive and G_{ω} simple non-abelian for all $\omega \in \Omega$.

Theorem

Let $G \leq \operatorname{Sym}(\Omega)$ be primitive and G_{ω} simple non-abelian for all $\omega \in \Omega$. Then Γ , Φ and Δ are the only (potential) G-invariant subgroups of K_G .

Theorem

Let $G \leq \operatorname{Sym}(\Omega)$ be primitive and G_{ω} simple non-abelian for all $\omega \in \Omega$. Then Γ , Φ and Δ are the only (potential) G-invariant subgroups of K_G .

Sketch of proof

Suppose $K \leq K_G$ is G-invariant.

Theorem

Let $G \leq \operatorname{Sym}(\Omega)$ be primitive and G_{ω} simple non-abelian for all $\omega \in \Omega$. Then Γ , Φ and Δ are the only (potential) G-invariant subgroups of K_G .

Sketch of proof

Suppose $K \leq K_G$ is G-invariant. Let $\pi_\omega : K_G \to G_\omega$ denote the natural projection.

Theorem

Let $G \leq \operatorname{Sym}(\Omega)$ be primitive and G_{ω} simple non-abelian for all $\omega \in \Omega$. Then Γ , Φ and Δ are the only (potential) G-invariant subgroups of K_G .

Sketch of proof

Suppose $K \leq K_G$ is G-invariant. Let $\pi_\omega : K_G \to G_\omega$ denote the natural projection. By G-invariance, the group $\pi_\omega(K)$ is normal in G_ω .

Theorem

Let $G \leq \operatorname{Sym}(\Omega)$ be primitive and G_{ω} simple non-abelian for all $\omega \in \Omega$. Then Γ , Φ and Δ are the only (potential) G-invariant subgroups of K_G .

Sketch of proof

Suppose $K \leq K_G$ is G-invariant. Let $\pi_\omega : K_G \to G_\omega$ denote the natural projection. By G-invariance, the group $\pi_\omega(K)$ is normal in G_ω . Since G_ω is simple, and G is transitive, either $\pi_\omega(K) = \{e\}$ for all $\omega \in \Omega$, or $\pi_\omega(K) = G_\omega$ for all $\omega \in \Omega$.

Theorem

Let $G \leq \operatorname{Sym}(\Omega)$ be primitive and G_{ω} simple non-abelian for all $\omega \in \Omega$. Then Γ , Φ and Δ are the only (potential) G-invariant subgroups of K_G .

Sketch of proof

Suppose $K \leq K_G$ is G-invariant. Let $\pi_\omega : K_G \to G_\omega$ denote the natural projection. By G-invariance, the group $\pi_\omega(K)$ is normal in G_ω . Since G_ω is simple, and G is transitive, either $\pi_\omega(K) = \{e\}$ for all $\omega \in \Omega$, or $\pi_\omega(K) = G_\omega$ for all $\omega \in \Omega$. In the first case, $K = \{e\} = \Gamma$.

Theorem

Let $G \leq \operatorname{Sym}(\Omega)$ be primitive and G_{ω} simple non-abelian for all $\omega \in \Omega$. Then Γ , Φ and Δ are the only (potential) G-invariant subgroups of K_G .

Sketch of proof

Suppose $K \leq K_G$ is G-invariant. Let $\pi_\omega : K_G \to G_\omega$ denote the natural projection. By G-invariance, the group $\pi_\omega(K)$ is normal in G_ω . Since G_ω is simple, and G is transitive, either $\pi_\omega(K) = \{e\}$ for all $\omega \in \Omega$, or $\pi_\omega(K) = G_\omega$ for all $\omega \in \Omega$. In the first case, $K = \{e\} = \Gamma$. In the second case there is, by transitivity of G, an isomorphism $\varphi : K_G \to G_\omega^d$.

Theorem

Let $G \leq \operatorname{Sym}(\Omega)$ be primitive and G_{ω} simple non-abelian for all $\omega \in \Omega$. Then Γ , Φ and Δ are the only (potential) G-invariant subgroups of K_G .

Sketch of proof

Suppose $K \leq K_G$ is G-invariant. Let $\pi_\omega: K_G \to G_\omega$ denote the natural projection. By G-invariance, the group $\pi_\omega(K)$ is normal in G_ω . Since G_ω is simple, and G is transitive, either $\pi_\omega(K) = \{e\}$ for all $\omega \in \Omega$, or $\pi_\omega(K) = G_\omega$ for all $\omega \in \Omega$. In the first case, $K = \{e\} = \Gamma$. In the second case there is, by transitivity of G, an isomorphism $\varphi: K_G \to G_{\omega_0}^d$. By [Rad17, Lemma 2.4], the group $\varphi(K)$ is a product of subdiagonals of $G_{\omega_0}^d$.

Theorem

Let $G \leq \operatorname{Sym}(\Omega)$ be primitive and G_{ω} simple non-abelian for all $\omega \in \Omega$. Then Γ , Φ and Δ are the only (potential) G-invariant subgroups of K_G .

Sketch of proof

Suppose $K \leq K_G$ is G-invariant. Let $\pi_\omega : K_G \to G_\omega$ denote the natural projection. By G-invariance, the group $\pi_\omega(K)$ is normal in G_ω . Since G_ω is simple, and G is transitive, either $\pi_\omega(K) = \{e\}$ for all $\omega \in \Omega$, or $\pi_\omega(K) = G_\omega$ for all $\omega \in \Omega$. In the first case, $K = \{e\} = \Gamma$. In the second case there is, by transitivity of G, an isomorphism $\varphi : K_G \to G_{\omega_0}^d$. By [Rad17, Lemma 2.4], the group $\varphi(K)$ is a product of subdiagonals of $G_{\omega_0}^d$. As G is primitive, the underlying partition of this product is trivial.

30/11/2021

Theorem

Let $G \leq \operatorname{Sym}(\Omega)$ be primitive and G_{ω} simple non-abelian for all $\omega \in \Omega$. Then Γ , Φ and Δ are the only (potential) G-invariant subgroups of K_G .

Sketch of proof

Suppose $K \leq K_G$ is G-invariant. Let $\pi_\omega : K_G \to G_\omega$ denote the natural projection. By G-invariance, the group $\pi_\omega(K)$ is normal in G_ω . Since G_ω is simple, and G is transitive, either $\pi_\omega(K) = \{e\}$ for all $\omega \in \Omega$, or $\pi_\omega(K) = G_\omega$ for all $\omega \in \Omega$. In the first case, $K = \{e\} = \Gamma$. In the second case there is, by transitivity of G, an isomorphism $\varphi : K_G \to G_{\omega_0}^d$. By [Rad17, Lemma 2.4], the group $\varphi(K)$ is a product of subdiagonals of $G_{\omega_0}^d$. As G is primitive, the underlying partition of this product is trivial. Hence either $K = \Phi = K_G$, or $K = \Delta$.