

Talk #9: Maltsev classification



Example

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization.

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization. I will expand by constants in each case.

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization. I will expand by constants in each case.

$$\mathbb{Z}_6 = \{0, 1, 2, 3, 4, 5\}:$$

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization. I will expand by constants in each case.

$\mathbb{Z}_6 = \{0, 1, 2, 3, 4, 5\}$:	This group has 12 nhoods.
---	---------------------------

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization. I will expand by constants in each case.

$\mathbb{Z}_6 = \{0, 1, 2, 3, 4, 5\}$: This group has 12 nhoods. It has a cover $\{U, V\}$ where $U = \{0, 3\} = e(\mathbb{Z}_6)$ for $e(x) = 3x$ and $V = \{0, 2, 4\} = f(\mathbb{Z}_6)$ for $f(x) = 4x$.

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization. I will expand by constants in each case.

$\mathbb{Z}_6 = \{0, 1, 2, 3, 4, 5\}$: This group has 12 nhoods. It has a cover $\{U, V\}$ where $U = \{0, 3\} = e(\mathbb{Z}_6)$ for $e(x) = 3x$ and $V = \{0, 2, 4\} = f(\mathbb{Z}_6)$ for $f(x) = 4x$. A decomposition equation is $x = \lambda(e\rho_1(x), f\rho_2(x))$ for $\lambda(x, y) = x + y$ and $\rho_1(x) = \rho_2(x) = x$.

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization. I will expand by constants in each case.

$\mathbb{Z}_6 = \{0, 1, 2, 3, 4, 5\}$: This group has 12 nhoods. It has a cover $\{U, V\}$ where $U = \{0, 3\} = e(\mathbb{Z}_6)$ for $e(x) = 3x$ and $V = \{0, 2, 4\} = f(\mathbb{Z}_6)$ for $f(x) = 4x$. A decomposition equation is $x = \lambda(e\rho_1(x), f\rho_2(x))$ for $\lambda(x, y) = x + y$ and $\rho_1(x) = \rho_2(x) = x$. The induced algebras $e(\mathbb{Z}_6) = \mathbb{Z}_6|_U$ and $f(\mathbb{Z}_6) = \mathbb{Z}_6|_V$ are polynomially equivalent to the 2-element group and the 3-element group, respectively.

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization. I will expand by constants in each case.

$\mathbb{Z}_6 = \{0, 1, 2, 3, 4, 5\}$: This group has 12 nhoods. It has a cover $\{U, V\}$ where $U = \{0, 3\} = e(\mathbb{Z}_6)$ for $e(x) = 3x$ and $V = \{0, 2, 4\} = f(\mathbb{Z}_6)$ for $f(x) = 4x$. A decomposition equation is $x = \lambda(e\rho_1(x), f\rho_2(x))$ for $\lambda(x, y) = x + y$ and $\rho_1(x) = \rho_2(x) = x$. The induced algebras $e(\mathbb{Z}_6) = \mathbb{Z}_6|_U$ and $f(\mathbb{Z}_6) = \mathbb{Z}_6|_V$ are polynomially equivalent to the 2-element group and the 3-element group, respectively.

$$D_3 = \{1, r, r^2, s, sr, sr^2\}:$$

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization. I will expand by constants in each case.

$\mathbb{Z}_6 = \{0, 1, 2, 3, 4, 5\}$: This group has 12 nhoods. It has a cover $\{U, V\}$ where $U = \{0, 3\} = e(\mathbb{Z}_6)$ for $e(x) = 3x$ and $V = \{0, 2, 4\} = f(\mathbb{Z}_6)$ for $f(x) = 4x$. A decomposition equation is $x = \lambda(e\rho_1(x), f\rho_2(x))$ for $\lambda(x, y) = x + y$ and $\rho_1(x) = \rho_2(x) = x$. The induced algebras $e(\mathbb{Z}_6) = \mathbb{Z}_6|_U$ and $f(\mathbb{Z}_6) = \mathbb{Z}_6|_V$ are polynomially equivalent to the 2-element group and the 3-element group, respectively.

$D_3 = \{1, r, r^2, s, sr, sr^2\}$: This group has ≥ 24 nhoods.

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization. I will expand by constants in each case.

$\mathbb{Z}_6 = \{0, 1, 2, 3, 4, 5\}$: This group has 12 nhoods. It has a cover $\{U, V\}$ where $U = \{0, 3\} = e(\mathbb{Z}_6)$ for $e(x) = 3x$ and $V = \{0, 2, 4\} = f(\mathbb{Z}_6)$ for $f(x) = 4x$. A decomposition equation is $x = \lambda(e\rho_1(x), f\rho_2(x))$ for $\lambda(x, y) = x + y$ and $\rho_1(x) = \rho_2(x) = x$. The induced algebras $e(\mathbb{Z}_6) = \mathbb{Z}_6|_U$ and $f(\mathbb{Z}_6) = \mathbb{Z}_6|_V$ are polynomially equivalent to the 2-element group and the 3-element group, respectively.

$D_3 = \{1, r, r^2, s, sr, sr^2\}$: This group has ≥ 24 nhoods. It has a cover $\{U, V\}$ where $U = \{1, s\} = e(D_3)$ for $e(x) = s(sx^3)^3$ and $V = \{1, r, r^2\} = f(D_3)$ for $f(x) = x^4(sx^4)$.

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization. I will expand by constants in each case.

$\mathbb{Z}_6 = \{0, 1, 2, 3, 4, 5\}$: This group has 12 nhoods. It has a cover $\{U, V\}$ where $U = \{0, 3\} = e(\mathbb{Z}_6)$ for $e(x) = 3x$ and $V = \{0, 2, 4\} = f(\mathbb{Z}_6)$ for $f(x) = 4x$. A decomposition equation is $x = \lambda(e\rho_1(x), f\rho_2(x))$ for $\lambda(x, y) = x + y$ and $\rho_1(x) = \rho_2(x) = x$. The induced algebras $e(\mathbb{Z}_6) = \mathbb{Z}_6|_U$ and $f(\mathbb{Z}_6) = \mathbb{Z}_6|_V$ are polynomially equivalent to the 2-element group and the 3-element group, respectively.

$D_3 = \{1, r, r^2, s, sr, sr^2\}$: This group has ≥ 24 nhoods. It has a cover $\{U, V\}$ where $U = \{1, s\} = e(D_3)$ for $e(x) = s(sx^3)^3$ and $V = \{1, r, r^2\} = f(D_3)$ for $f(x) = x^4(sx^4)$. A decomposition equation is $x = \lambda(e\rho_1(x), f\rho_2(x))$ for $\lambda(x, y) = x \cdot y$ and $\rho_1(x) = \rho_2(x) = x$.

Example

Let's compare the two 6-element groups \mathbb{Z}_6 and D_3 with respect to localization. I will expand by constants in each case.

$\mathbb{Z}_6 = \{0, 1, 2, 3, 4, 5\}$: This group has 12 nhoods. It has a cover $\{U, V\}$ where $U = \{0, 3\} = e(\mathbb{Z}_6)$ for $e(x) = 3x$ and $V = \{0, 2, 4\} = f(\mathbb{Z}_6)$ for $f(x) = 4x$. A decomposition equation is $x = \lambda(e\rho_1(x), f\rho_2(x))$ for $\lambda(x, y) = x + y$ and $\rho_1(x) = \rho_2(x) = x$. The induced algebras $e(\mathbb{Z}_6) = \mathbb{Z}_6|_U$ and $f(\mathbb{Z}_6) = \mathbb{Z}_6|_V$ are polynomially equivalent to the 2-element group and the 3-element group, respectively.

$D_3 = \{1, r, r^2, s, sr, sr^2\}$: This group has ≥ 24 nhoods. It has a cover $\{U, V\}$ where $U = \{1, s\} = e(D_3)$ for $e(x) = s(sx^3)^3$ and $V = \{1, r, r^2\} = f(D_3)$ for $f(x) = x^4(sx^4)$. A decomposition equation is $x = \lambda(e\rho_1(x), f\rho_2(x))$ for $\lambda(x, y) = x \cdot y$ and $\rho_1(x) = \rho_2(x) = x$. The induced algebras $f(D_3) = D_3|_U$ and $f(D_3) = D_3|_V$ are polynomially equivalent to the 2-element group and the 3-element group, respectively.

Question

Question

- ① Locally, \mathbb{Z}_6 and D_3 look the same.

Question

- ① Locally, \mathbb{Z}_6 and D_3 look the same.

Question

- ① Locally, \mathbb{Z}_6 and D_3 look the same. Locally, each group is covered by neighborhoods that are abelian subgroups.

- ① Locally, \mathbb{Z}_6 and D_3 look the same. Locally, each group is covered by neighborhoods that are abelian subgroups. There is a bijection between isomorphism types of subgroups in the covers.

Question

- ① Locally, \mathbb{Z}_6 and D_3 look the same. Locally, each group is covered by neighborhoods that are abelian subgroups. There is a bijection between isomorphism types of subgroups in the covers.
- ② Even the decomposition equations look the same.

Question

- 1 Locally, \mathbb{Z}_6 and D_3 look the same. Locally, each group is covered by neighborhoods that are abelian subgroups. There is a bijection between isomorphism types of subgroups in the covers.
- 2 Even the decomposition equations look the same.

Question

- ① Locally, \mathbb{Z}_6 and D_3 look the same. Locally, each group is covered by neighborhoods that are abelian subgroups. There is a bijection between isomorphism types of subgroups in the covers.
- ② Even the decomposition equations look the same.
- ③ Why is one of the groups abelian and the other is not?

Question

- ① Locally, \mathbb{Z}_6 and D_3 look the same. Locally, each group is covered by neighborhoods that are abelian subgroups. There is a bijection between isomorphism types of subgroups in the covers.
- ② Even the decomposition equations look the same.
- ③ Why is one of the groups abelian and the other is not?

Question

- ① Locally, \mathbb{Z}_6 and D_3 look the same. Locally, each group is covered by neighborhoods that are abelian subgroups. There is a bijection between isomorphism types of subgroups in the covers.
- ② Even the decomposition equations look the same.
- ③ Why is one of the groups abelian and the other is not?

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$.

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp .

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp .

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$ in a way that is dictated by the decomposition equation.

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$ in a way that is dictated by the decomposition equation. For the product to make sense, we need the signatures of the factors to be the same so that we can assign a signature to the product.

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$ in a way that is dictated by the decomposition equation. For the product to make sense, we need the signatures of the factors to be the same so that we can assign a signature to the product. These signatures are those inherited from \mathbf{A}^\perp .

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$ in a way that is dictated by the decomposition equation. For the product to make sense, we need the signatures of the factors to be the same so that we can assign a signature to the product. These signatures are those inherited from \mathbf{A}^\perp .

A group G is abelian if and only if the graph the Maltsev operation is a compatible 4-ary relation:

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$ in a way that is dictated by the decomposition equation. For the product to make sense, we need the signatures of the factors to be the same so that we can assign a signature to the product. These signatures are those inherited from \mathbf{A}^\perp .

A group G is abelian if and only if the graph the Maltsev operation is a compatible 4-ary relation:

$$\rho_G = \{(x, y, z, xy^{-1}z) \mid (x, y, z) \in G^3\} \leq G^4.$$

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$ in a way that is dictated by the decomposition equation. For the product to make sense, we need the signatures of the factors to be the same so that we can assign a signature to the product. These signatures are those inherited from \mathbf{A}^\perp .

A group G is abelian if and only if the graph the Maltsev operation is a compatible 4-ary relation:

$$\rho_G = \{(x, y, z, xy^{-1}z) \mid (x, y, z) \in G^3\} \leq G^4.$$

\mathbb{Z}_6 is abelian,

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$ in a way that is dictated by the decomposition equation. For the product to make sense, we need the signatures of the factors to be the same so that we can assign a signature to the product. These signatures are those inherited from \mathbf{A}^\perp .

A group G is abelian if and only if the graph the Maltsev operation is a compatible 4-ary relation:

$$\rho_G = \{(x, y, z, xy^{-1}z) \mid (x, y, z) \in G^3\} \leq G^4.$$

\mathbb{Z}_6 is abelian, so $\rho_{\mathbb{Z}_6}$ is a basic relation of \mathbb{Z}_6^\perp

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$ in a way that is dictated by the decomposition equation. For the product to make sense, we need the signatures of the factors to be the same so that we can assign a signature to the product. These signatures are those inherited from \mathbf{A}^\perp .

A group G is abelian if and only if the graph the Maltsev operation is a compatible 4-ary relation:

$$\rho_G = \{(x, y, z, xy^{-1}z) \mid (x, y, z) \in G^3\} \leq G^4.$$

\mathbb{Z}_6 is abelian, so $\rho_{\mathbb{Z}_6}$ is a basic relation of \mathbb{Z}_6^\perp and $\rho_{\mathbb{Z}_6}|_U = \rho_U$ and $\rho_{\mathbb{Z}_6}|_V = \rho_V$.

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$ in a way that is dictated by the decomposition equation. For the product to make sense, we need the signatures of the factors to be the same so that we can assign a signature to the product. These signatures are those inherited from \mathbf{A}^\perp .

A group G is abelian if and only if the graph the Maltsev operation is a compatible 4-ary relation:

$$\rho_G = \{(x, y, z, xy^{-1}z) \mid (x, y, z) \in G^3\} \leq G^4.$$

\mathbb{Z}_6 is abelian, so $\rho_{\mathbb{Z}_6}$ is a basic relation of \mathbb{Z}_6^\perp and $\rho_{\mathbb{Z}_6}|_U = \rho_U$ and $\rho_{\mathbb{Z}_6}|_V = \rho_V$. On the other hand, there is no compatible relation R of D_3 such that $R|_U = \rho_U$ and $R|_V = \rho_V$.

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$ in a way that is dictated by the decomposition equation. For the product to make sense, we need the signatures of the factors to be the same so that we can assign a signature to the product. These signatures are those inherited from \mathbf{A}^\perp .

A group G is abelian if and only if the graph the Maltsev operation is a compatible 4-ary relation:

$$\rho_G = \{(x, y, z, xy^{-1}z) \mid (x, y, z) \in G^3\} \leq G^4.$$

\mathbb{Z}_6 is abelian, so $\rho_{\mathbb{Z}_6}$ is a basic relation of \mathbb{Z}_6^\perp and $\rho_{\mathbb{Z}_6}|_U = \rho_U$ and $\rho_{\mathbb{Z}_6}|_V = \rho_V$. On the other hand, there is no compatible relation R of D_3 such that $R|_U = \rho_U$ and $R|_V = \rho_V$. Conclusion:

Recall

We are studying \mathbf{A} from a relational point of view, $\mathbf{A}^\perp = \langle A; \text{Rel}(\mathbf{A}) \rangle$. Each compatible relation of \mathbf{A} is taken to be a basic relation of \mathbf{A}^\perp . This fixes a relational signature for \mathbf{A}^\perp .

Starting with a cover $\mathcal{C} = \{U_1, \dots, U_n\}$ of \mathbf{A} , we define relational restrictions $\mathbf{A}^\perp|_{U_i}$ of the same relational signature as \mathbf{A}^\perp . \mathbf{A}^\perp is recoverable as a retract of a product of copies of the structures $\mathbf{A}|_{U_i}$ in a way that is dictated by the decomposition equation. For the product to make sense, we need the signatures of the factors to be the same so that we can assign a signature to the product. These signatures are those inherited from \mathbf{A}^\perp .

A group G is abelian if and only if the graph the Maltsev operation is a compatible 4-ary relation:

$$\rho_G = \{(x, y, z, xy^{-1}z) \mid (x, y, z) \in G^3\} \leq G^4.$$

\mathbb{Z}_6 is abelian, so $\rho_{\mathbb{Z}_6}$ is a basic relation of \mathbb{Z}_6^\perp and $\rho_{\mathbb{Z}_6}|_U = \rho_U$ and $\rho_{\mathbb{Z}_6}|_V = \rho_V$. On the other hand, there is no compatible relation R of D_3 such that $R|_U = \rho_U$ and $R|_V = \rho_V$. Conclusion: Local abelianness does not imply global abelianness because of signature differences.

Linear Maltsev conditions, 1

Linear Maltsev conditions, 1

We will argue that satisfaction of linear Maltsev conditions is both preserved and reflected by localization to a cover.

Linear Maltsev conditions, 1

We will argue that satisfaction of linear Maltsev conditions is both preserved and reflected by localization to a cover.

Examples.

Linear Maltsev conditions, 1

We will argue that satisfaction of linear Maltsev conditions is both preserved and reflected by localization to a cover.

Examples.

- ① A Maltsev term for a variety \mathcal{V} is a term $M(x, y, z)$ such that

$$\mathcal{V} \models M(x, y, y) \approx x, \quad M(x, x, y) \approx y.$$

Linear Maltsev conditions, 1

We will argue that satisfaction of linear Maltsev conditions is both preserved and reflected by localization to a cover.

Examples.

- ① A Maltsev term for a variety \mathcal{V} is a term $M(x, y, z)$ such that

$$\mathcal{V} \models M(x, y, y) \approx x, \quad M(x, x, y) \approx y.$$

- ② A majority term for a variety \mathcal{V} is a term $m(x, y, z)$ such that

$$\mathcal{V} \models m(x, x, y) \approx m(x, y, x) \approx m(y, x, x) \approx x.$$

Linear Maltsev conditions, 1

We will argue that satisfaction of linear Maltsev conditions is both preserved and reflected by localization to a cover.

Examples.

- 1 A Maltsev term for a variety \mathcal{V} is a term $M(x, y, z)$ such that

$$\mathcal{V} \models M(x, y, y) \approx x, \quad M(x, x, y) \approx y.$$

- 2 A majority term for a variety \mathcal{V} is a term $m(x, y, z)$ such that

$$\mathcal{V} \models m(x, x, y) \approx m(x, y, x) \approx m(y, x, x) \approx x.$$

- 3 A ‘rare area’ term for a variety \mathcal{V} is a term $t(w, x, y, z)$ such that

$$\mathcal{V} \models t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

Linear Maltsev conditions, 2

Linear Maltsev conditions, 2

Definitions.

Linear Maltsev conditions, 2

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Linear Maltsev conditions, 2

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} ,

Linear Maltsev conditions, 2

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} , \mathcal{V} satisfies Σ as a Maltsev condition if \mathcal{V} has a term $s^{\mathcal{V}}$ for each basic operation symbol s of \mathcal{L} and $\mathcal{V} \models s^{\mathcal{V}} \approx t^{\mathcal{V}}$ for each identity $s \approx t$ in Σ .

Linear Maltsev conditions, 2

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} , \mathcal{V} satisfies Σ as a Maltsev condition if \mathcal{V} has a term $s^{\mathcal{V}}$ for each basic operation symbol s of \mathcal{L} and $\mathcal{V} \models s^{\mathcal{V}} \approx t^{\mathcal{V}}$ for each identity $s \approx t$ in Σ . Maltsev conditions of this type are called **linear**.

Linear Maltsev conditions, 2

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} , \mathcal{V} satisfies Σ as a Maltsev condition if \mathcal{V} has a term $s^{\mathcal{V}}$ for each basic operation symbol s of \mathcal{L} and $\mathcal{V} \models s^{\mathcal{V}} \approx t^{\mathcal{V}}$ for each identity $s \approx t$ in Σ . Maltsev conditions of this type are called **linear**.

Examples.

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} , \mathcal{V} satisfies Σ as a Maltsev condition if \mathcal{V} has a term $s^\mathcal{V}$ for each basic operation symbol s of \mathcal{L} and $\mathcal{V} \models s^\mathcal{V} \approx t^\mathcal{V}$ for each identity $s \approx t$ in Σ . Maltsev conditions of this type are called **linear**.

Examples.

- 1 A variety is congruence 3-permutable iff it has terms $p(x, y, z)$ and $q(x, y, z)$ such that

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} , \mathcal{V} satisfies Σ as a Maltsev condition if \mathcal{V} has a term $s^\mathcal{V}$ for each basic operation symbol s of \mathcal{L} and $\mathcal{V} \models s^\mathcal{V} \approx t^\mathcal{V}$ for each identity $s \approx t$ in Σ . Maltsev conditions of this type are called **linear**.

Examples.

- 1 A variety is congruence 3-permutable iff it has terms $p(x, y, z)$ and $q(x, y, z)$ such that

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} , \mathcal{V} satisfies Σ as a Maltsev condition if \mathcal{V} has a term $s^\mathcal{V}$ for each basic operation symbol s of \mathcal{L} and $\mathcal{V} \models s^\mathcal{V} \approx t^\mathcal{V}$ for each identity $s \approx t$ in Σ . Maltsev conditions of this type are called **linear**.

Examples.

- 1 A variety is congruence 3-permutable iff it has terms $p(x, y, z)$ and $q(x, y, z)$ such that

$$\mathcal{V} \models x \approx p(x, z, z), \quad p(x, x, z) \approx q(x, z, z), \quad q(x, x, z) \approx z.$$

Linear Maltsev conditions, 2

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} , \mathcal{V} satisfies Σ as a Maltsev condition if \mathcal{V} has a term $s^\mathcal{V}$ for each basic operation symbol s of \mathcal{L} and $\mathcal{V} \models s^\mathcal{V} \approx t^\mathcal{V}$ for each identity $s \approx t$ in Σ . Maltsev conditions of this type are called **linear**.

Examples.

- 1 A variety is congruence 3-permutable iff it has terms $p(x, y, z)$ and $q(x, y, z)$ such that

$$\mathcal{V} \models x \approx p(x, z, z), \quad p(x, x, z) \approx q(x, z, z), \quad q(x, x, z) \approx z.$$

(Linear.)

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} , \mathcal{V} satisfies Σ as a Maltsev condition if \mathcal{V} has a term $s^\mathcal{V}$ for each basic operation symbol s of \mathcal{L} and $\mathcal{V} \models s^\mathcal{V} \approx t^\mathcal{V}$ for each identity $s \approx t$ in Σ . Maltsev conditions of this type are called **linear**.

Examples.

- 1 A variety is congruence 3-permutable iff it has terms $p(x, y, z)$ and $q(x, y, z)$ such that

$$\mathcal{V} \models x \approx p(x, z, z), \quad p(x, x, z) \approx q(x, z, z), \quad q(x, x, z) \approx z.$$

(Linear.)

- 2 A variety has an underlying semilattice term iff it has a term $x \wedge y$ such that

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} , \mathcal{V} satisfies Σ as a Maltsev condition if \mathcal{V} has a term $s^\mathcal{V}$ for each basic operation symbol s of \mathcal{L} and $\mathcal{V} \models s^\mathcal{V} \approx t^\mathcal{V}$ for each identity $s \approx t$ in Σ . Maltsev conditions of this type are called **linear**.

Examples.

- 1 A variety is congruence 3-permutable iff it has terms $p(x, y, z)$ and $q(x, y, z)$ such that

$$\mathcal{V} \models x \approx p(x, z, z), \quad p(x, x, z) \approx q(x, z, z), \quad q(x, x, z) \approx z.$$

(Linear.)

- 2 A variety has an underlying semilattice term iff it has a term $x \wedge y$ such that

Linear Maltsev conditions, 2

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} , \mathcal{V} satisfies Σ as a Maltsev condition if \mathcal{V} has a term $s^\mathcal{V}$ for each basic operation symbol s of \mathcal{L} and $\mathcal{V} \models s^\mathcal{V} \approx t^\mathcal{V}$ for each identity $s \approx t$ in Σ . Maltsev conditions of this type are called **linear**.

Examples.

- 1 A variety is congruence 3-permutable iff it has terms $p(x, y, z)$ and $q(x, y, z)$ such that

$$\mathcal{V} \models x \approx p(x, z, z), \quad p(x, x, z) \approx q(x, z, z), \quad q(x, x, z) \approx z.$$

(Linear.)

- 2 A variety has an underlying semilattice term iff it has a term $x \wedge y$ such that

$$\mathcal{V} \models x \approx x \wedge x, \quad x \wedge y \approx y \wedge x, \quad x \wedge (y \wedge z) \approx (x \wedge y) \wedge z.$$

Definitions.

Given an algebraic language \mathcal{L} , a **height-1 identity** is an identity of the form $s(\mathbf{x}) \approx t(\mathbf{x})$ where s and t are \mathcal{L} -operation symbols or variables.

Given a set Σ of height-1 identities in the language \mathcal{L} , \mathcal{V} satisfies Σ as a Maltsev condition if \mathcal{V} has a term $s^{\mathcal{V}}$ for each basic operation symbol s of \mathcal{L} and $\mathcal{V} \models s^{\mathcal{V}} \approx t^{\mathcal{V}}$ for each identity $s \approx t$ in Σ . Maltsev conditions of this type are called **linear**.

Examples.

- 1 A variety is congruence 3-permutable iff it has terms $p(x, y, z)$ and $q(x, y, z)$ such that

$$\mathcal{V} \models x \approx p(x, z, z), \quad p(x, x, z) \approx q(x, z, z), \quad q(x, x, z) \approx z.$$

(Linear.)

- 2 A variety has an underlying semilattice term iff it has a term $x \wedge y$ such that

$$\mathcal{V} \models x \approx x \wedge x, \quad x \wedge y \approx y \wedge x, \quad x \wedge (y \wedge z) \approx (x \wedge y) \wedge z.$$

(Not linear.)

Linear Maltsev conditions, 3

Theorem.

Theorem. The satisfaction of a fixed linear Maltsev condition is both preserved and reflected by localization to neighborhoods in a cover.

Theorem. The satisfaction of a fixed linear Maltsev condition is both preserved and reflected by localization to neighborhoods in a cover.

Proof sketch.

Theorem. The satisfaction of a fixed linear Maltsev condition is both preserved and reflected by localization to neighborhoods in a cover.

Proof sketch. I will illustrate the idea of the proof with a ‘sufficiently general’ example:

Theorem. The satisfaction of a fixed linear Maltsev condition is both preserved and reflected by localization to neighborhoods in a cover.

Proof sketch. I will illustrate the idea of the proof with a ‘sufficiently general’ example: $p(x, x, z) \approx q(x, z, z)$.

Linear Maltsev conditions, 3

Theorem. The satisfaction of a fixed linear Maltsev condition is both preserved and reflected by localization to neighborhoods in a cover.

Proof sketch. I will illustrate the idea of the proof with a ‘sufficiently general’ example: $p(x, x, z) \approx q(x, z, z)$.

Assume that \mathbf{A} is covered by $\mathcal{C} = \{U_i\}$, $e_i(A) = U_i$, and the decomposition equation is

Theorem. The satisfaction of a fixed linear Maltsev condition is both preserved and reflected by localization to neighborhoods in a cover.

Proof sketch. I will illustrate the idea of the proof with a ‘sufficiently general’ example: $p(x, x, z) \approx q(x, z, z)$.

Assume that \mathbf{A} is covered by $\mathcal{C} = \{U_i\}$, $e_i(A) = U_i$, and the decomposition equation is

$$x = \lambda(e_{i_1}\rho_{i_1}(x), \dots, e_{i_k}\rho_{i_k}(x)).$$

Theorem. The satisfaction of a fixed linear Maltsev condition is both preserved and reflected by localization to neighborhoods in a cover.

Proof sketch. I will illustrate the idea of the proof with a ‘sufficiently general’ example: $p(x, x, z) \approx q(x, z, z)$.

Assume that \mathbf{A} is covered by $\mathcal{C} = \{U_i\}$, $e_i(A) = U_i$, and the decomposition equation is

$$x = \lambda(e_{i_1}\rho_{i_1}(x), \dots, e_{i_k}\rho_{i_k}(x)).$$

Note:

Theorem. The satisfaction of a fixed linear Maltsev condition is both preserved and reflected by localization to neighborhoods in a cover.

Proof sketch. I will illustrate the idea of the proof with a ‘sufficiently general’ example: $p(x, x, z) \approx q(x, z, z)$.

Assume that \mathbf{A} is covered by $\mathcal{C} = \{U_i\}$, $e_i(A) = U_i$, and the decomposition equation is

$$x = \lambda(e_{i_1}\rho_{i_1}(x), \dots, e_{i_k}\rho_{i_k}(x)).$$

Note: I am not replacing \mathbf{A} by its polynomial expansion for this result. I am assuming that λ, ρ_i, e_i are \mathcal{V} -terms and $\mathcal{V} \models e_i(e_i(x)) \approx x$ and $\mathcal{V} \models \lambda(\overline{e_i\rho_i(x)}) \approx x$.

Linear Maltsev conditions, 4

Linear Maltsev conditions, 4

- 1 (Localization to $e_i(A) = U_i$)

Linear Maltsev conditions, 4

- 1 (Localization to $e_i(A) = U_i$)

Linear Maltsev conditions, 4

① (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$.

Linear Maltsev conditions, 4

① (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

Linear Maltsev conditions, 4

① (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

② (Globalization)

Linear Maltsev conditions, 4

① (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

② (Globalization)

Linear Maltsev conditions, 4

① (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

② (Globalization)

Suppose that $p_i(x, x, z) \approx q_i(x, z, z)$ on $\mathbf{A}|_{U_i}$.

Linear Maltsev conditions, 4

① (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

② (Globalization)

Suppose that $p_i(x, x, z) \approx q_i(x, z, z)$ on $\mathbf{A}|_{U_i}$. Replace the family of (p_i, q_i) ,

Linear Maltsev conditions, 4

① (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

② (Globalization)

Suppose that $p_i(x, x, z) \approx q_i(x, z, z)$ on $\mathbf{A}|_{U_i}$. Replace the family of (p_i, q_i) , defined on U_i and satisfying $p_i(x, x, z) \approx q_i(x, z, z)$ with

Linear Maltsev conditions, 4

① (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

② (Globalization)

Suppose that $p_i(x, x, z) \approx q_i(x, z, z)$ on $\mathbf{A}|_{U_i}$. Replace the family of (p_i, q_i) , defined on U_i and satisfying $p_i(x, x, z) \approx q_i(x, z, z)$ with

$$P(x, y, z) = \lambda(p_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

Linear Maltsev conditions, 4

1 (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

2 (Globalization)

Suppose that $p_i(x, x, z) \approx q_i(x, z, z)$ on $\mathbf{A}|_{U_i}$. Replace the family of (p_i, q_i) , defined on U_i and satisfying $p_i(x, x, z) \approx q_i(x, z, z)$ with

$$P(x, y, z) = \lambda(p_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

$$Q(x, y, z) = \lambda(q_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

Linear Maltsev conditions, 4

1 (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

2 (Globalization)

Suppose that $p_i(x, x, z) \approx q_i(x, z, z)$ on $\mathbf{A}|_{U_i}$. Replace the family of (p_i, q_i) , defined on U_i and satisfying $p_i(x, x, z) \approx q_i(x, z, z)$ with

$$P(x, y, z) = \lambda(p_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

$$Q(x, y, z) = \lambda(q_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

Claim:

Linear Maltsev conditions, 4

① (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

② (Globalization)

Suppose that $p_i(x, x, z) \approx q_i(x, z, z)$ on $\mathbf{A}|_{U_i}$. Replace the family of (p_i, q_i) , defined on U_i and satisfying $p_i(x, x, z) \approx q_i(x, z, z)$ with

$$P(x, y, z) = \lambda(p_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

$$Q(x, y, z) = \lambda(q_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

Claim: P and Q are terms of \mathbf{A} satisfying $P(x, x, z) \approx Q(x, z, z)$ on \mathbf{A} .

Linear Maltsev conditions, 4

1 (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

2 (Globalization)

Suppose that $p_i(x, x, z) \approx q_i(x, z, z)$ on $\mathbf{A}|_{U_i}$. Replace the family of (p_i, q_i) , defined on U_i and satisfying $p_i(x, x, z) \approx q_i(x, z, z)$ with

$$P(x, y, z) = \lambda(p_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

$$Q(x, y, z) = \lambda(q_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

Claim: P and Q are terms of \mathbf{A} satisfying $P(x, x, z) \approx Q(x, z, z)$ on \mathbf{A} . If, say, $p(x, y, z)$ is a variable,

Linear Maltsev conditions, 4

1 (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

2 (Globalization)

Suppose that $p_i(x, x, z) \approx q_i(x, z, z)$ on $\mathbf{A}|_{U_i}$. Replace the family of (p_i, q_i) , defined on U_i and satisfying $p_i(x, x, z) \approx q_i(x, z, z)$ with

$$P(x, y, z) = \lambda(p_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

$$Q(x, y, z) = \lambda(q_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

Claim: P and Q are terms of \mathbf{A} satisfying $P(x, x, z) \approx Q(x, z, z)$ on \mathbf{A} . If, say, $p(x, y, z)$ is a variable, then $P(x, y, z)$ is the same variable.

Linear Maltsev conditions, 4

1 (Localization to $e_i(A) = U_i$)

Replace $p(x, y, z)$ with $P(x, y, z) = e_i p(x, y, z)$ and $q(x, y, z)$ with $Q(x, y, z) = e_i q(x, y, z)$. The linear identity $p(x, x, z) \approx q(x, z, z)$ on \mathbf{A} induces $P(x, x, z) \approx Q(x, z, z)$ on $\mathbf{A}|_{U_i}$.

2 (Globalization)

Suppose that $p_i(x, x, z) \approx q_i(x, z, z)$ on $\mathbf{A}|_{U_i}$. Replace the family of (p_i, q_i) , defined on U_i and satisfying $p_i(x, x, z) \approx q_i(x, z, z)$ with

$$P(x, y, z) = \lambda(p_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

$$Q(x, y, z) = \lambda(q_{i_1}(e_{i_1}\rho_{i_1}(x), e_{i_1}\rho_{i_1}(y), e_{i_1}\rho_{i_1}(z)), \dots)$$

Claim: P and Q are terms of \mathbf{A} satisfying $P(x, x, z) \approx Q(x, z, z)$ on \mathbf{A} . If, say, $p(x, y, z)$ is a variable, then $P(x, y, z)$ is the same variable. \square

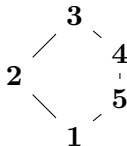
A summary of Chapter 9 results

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

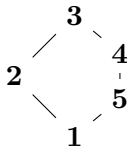
A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.



A summary of Chapter 9 results

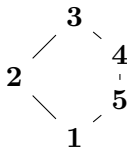
Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.



There are 6 main theorems of this type in Chapter 9,

A summary of Chapter 9 results

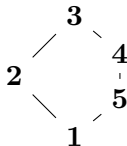
Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.



There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

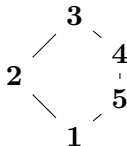


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

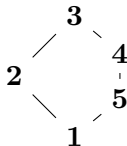


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

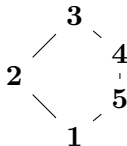


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

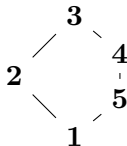


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

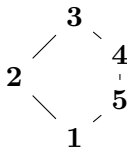


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

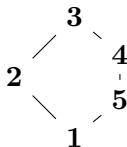


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

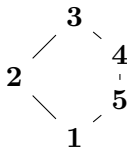


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

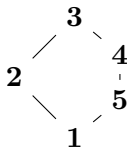


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

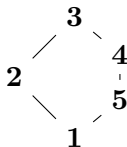


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$ (Theorem 9.10).

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

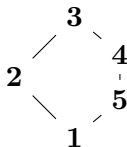


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$ (Theorem 9.10).
- ④ $\{1, 2, 5\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

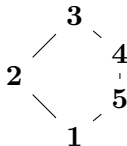


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$ (Theorem 9.10).
- ④ $\{1, 2, 5\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

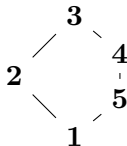


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$ (Theorem 9.10).
- ④ $\{1, 2, 5\}$ (Theorem 9.11).

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

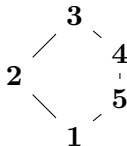


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$ (Theorem 9.10).
- ④ $\{1, 2, 5\}$ (Theorem 9.11).
- ⑤ $\{1, 4, 5\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

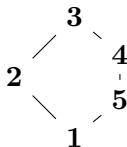


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$ (Theorem 9.10).
- ④ $\{1, 2, 5\}$ (Theorem 9.11).
- ⑤ $\{1, 4, 5\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

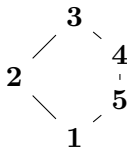


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$ (Theorem 9.10).
- ④ $\{1, 2, 5\}$ (Theorem 9.11).
- ⑤ $\{1, 4, 5\}$ (Theorem 9.14).

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

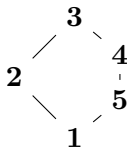


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$ (Theorem 9.10).
- ④ $\{1, 2, 5\}$ (Theorem 9.11).
- ⑤ $\{1, 4, 5\}$ (Theorem 9.14).
- ⑥ $\{1, 2, 4, 5\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

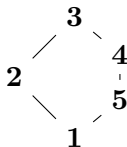


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$ (Theorem 9.10).
- ④ $\{1, 2, 5\}$ (Theorem 9.11).
- ⑤ $\{1, 4, 5\}$ (Theorem 9.14).
- ⑥ $\{1, 2, 4, 5\}$

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.

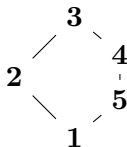


There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$ (Theorem 9.10).
- ④ $\{1, 2, 5\}$ (Theorem 9.11).
- ⑤ $\{1, 4, 5\}$ (Theorem 9.14).
- ⑥ $\{1, 2, 4, 5\}$ (Theorem 9.15).

A summary of Chapter 9 results

Chapter 9 proves that the property “ \mathcal{V} omits an order ideal I of types” may be characterized by an idempotent linear Maltsev condition.



There are 6 main theorems of this type in Chapter 9, which characterize when a locally finite variety omits the types in I where I is one of the 6 ideals

- ① $\{1\}$ (Theorem 9.6).
- ② $\{1, 5\}$ (Theorem 9.8).
- ③ $\{1, 2\}$ (Theorem 9.10).
- ④ $\{1, 2, 5\}$ (Theorem 9.11).
- ⑤ $\{1, 4, 5\}$ (Theorem 9.14).
- ⑥ $\{1, 2, 4, 5\}$ (Theorem 9.15).

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

① $\mathcal{V} \models T(x, x, \dots, x) \approx x,$

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

① $\mathcal{V} \models T(x, x, \dots, x) \approx x,$

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

- ① $\mathcal{V} \models T(x, x, \dots, x) \approx x$,
- ② \mathcal{V} satisfies a system of identities of the form

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

- ① $\mathcal{V} \models T(x, x, \dots, x) \approx x$,
- ② \mathcal{V} satisfies a system of identities of the form

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

- ① $\mathcal{V} \models T(x, x, \dots, x) \approx x$,
- ② \mathcal{V} satisfies a system of identities of the form

$$\begin{aligned}T(x, \square, \dots, \square) &\approx T(y, \square, \dots, \square) \\T(\square, x, \dots, \square) &\approx T(\square, y, \dots, \square) \\&\vdots \\T(\square, \square, \dots, x) &\approx T(\square, \square, \dots, y)\end{aligned}$$

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

- ① $\mathcal{V} \models T(x, x, \dots, x) \approx x$,
- ② \mathcal{V} satisfies a system of identities of the form

$$\begin{aligned}T(x, \square, \dots, \square) &\approx T(y, \square, \dots, \square) \\T(\square, x, \dots, \square) &\approx T(\square, y, \dots, \square) \\&\vdots \\T(\square, \square, \dots, x) &\approx T(\square, \square, \dots, y)\end{aligned}$$

(Each \square represents some - any - variable.)

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

- ① $\mathcal{V} \models T(x, x, \dots, x) \approx x$,
- ② \mathcal{V} satisfies a system of identities of the form

$$\begin{aligned}T(x, \square, \dots, \square) &\approx T(y, \square, \dots, \square) \\T(\square, x, \dots, \square) &\approx T(\square, y, \dots, \square) \\&\vdots \\T(\square, \square, \dots, x) &\approx T(\square, \square, \dots, y)\end{aligned}$$

(Each \square represents some - any - variable.)

Taylor's motivation:

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

- ① $\mathcal{V} \models T(x, x, \dots, x) \approx x$,
- ② \mathcal{V} satisfies a system of identities of the form

$$\begin{aligned}T(x, \square, \dots, \square) &\approx T(y, \square, \dots, \square) \\T(\square, x, \dots, \square) &\approx T(\square, y, \dots, \square) \\&\vdots \\T(\square, \square, \dots, x) &\approx T(\square, \square, \dots, y)\end{aligned}$$

(Each \square represents some - any - variable.)

Taylor's motivation: In 1924, Schreier proved that the homotopy group of any topological group is abelian.

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

- ① $\mathcal{V} \models T(x, x, \dots, x) \approx x$,
- ② \mathcal{V} satisfies a system of identities of the form

$$\begin{aligned}T(x, \square, \dots, \square) &\approx T(y, \square, \dots, \square) \\T(\square, x, \dots, \square) &\approx T(\square, y, \dots, \square) \\&\vdots \\T(\square, \square, \dots, x) &\approx T(\square, \square, \dots, y)\end{aligned}$$

(Each \square represents some - any - variable.)

Taylor's motivation: In 1924, Schreier proved that the homotopy group of any topological group is abelian. Taylor proved that the class of varieties satisfying the property “Every arc component of every topological algebra in \mathcal{V} has abelian homotopy group” is definable by an idempotent linear Maltsev condition.

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

- ① $\mathcal{V} \models T(x, x, \dots, x) \approx x$,
- ② \mathcal{V} satisfies a system of identities of the form

$$\begin{aligned}T(x, \square, \dots, \square) &\approx T(y, \square, \dots, \square) \\T(\square, x, \dots, \square) &\approx T(\square, y, \dots, \square) \\&\vdots \\T(\square, \square, \dots, x) &\approx T(\square, \square, \dots, y)\end{aligned}$$

(Each \square represents some - any - variable.)

Taylor's motivation: In 1924, Schreier proved that the homotopy group of any topological group is abelian. Taylor proved that the class of varieties satisfying the property “Every arc component of every topological algebra in \mathcal{V} has abelian homotopy group” is definable by an idempotent linear Maltsev condition. It turns out that his 1977 Maltsev condition,

Varieties that omit type 1

Definition. A **Taylor term** for \mathcal{V} is a \mathcal{V} -term $T(x_1, x_2, \dots, x_n)$ such that

- ① $\mathcal{V} \models T(x, x, \dots, x) \approx x$,
- ② \mathcal{V} satisfies a system of identities of the form

$$\begin{aligned}T(x, \square, \dots, \square) &\approx T(y, \square, \dots, \square) \\T(\square, x, \dots, \square) &\approx T(\square, y, \dots, \square) \\&\vdots \\T(\square, \square, \dots, x) &\approx T(\square, \square, \dots, y)\end{aligned}$$

(Each \square represents some - any - variable.)

Taylor's motivation: In 1924, Schreier proved that the homotopy group of any topological group is abelian. Taylor proved that the class of varieties satisfying the property “Every arc component of every topological algebra in \mathcal{V} has abelian homotopy group” is definable by an idempotent linear Maltsev condition. It turns out that his 1977 Maltsev condition, that \mathcal{V} has a Taylor term, is the weakest nontrivial idempotent linear Maltsev condition.

A characterization theorem

A characterization theorem

Theorem.

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- 1 \mathcal{V} omits type **1**.

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- 1 \mathcal{V} omits type **1**.

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- 1 \mathcal{V} omits type **1**.
- 2 \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- 1 \mathcal{V} omits type **1**.
- 2 \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- 1 \mathcal{V} omits type **1**.
- 2 \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- 3 \mathcal{V} has an n -ary Taylor term for some n .

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- 1 \mathcal{V} omits type **1**.
- 2 \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- 3 \mathcal{V} has an n -ary Taylor term for some n .

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010)

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010)

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term.

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- 1 \mathcal{V} omits type **1**.
- 2 \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- 3 \mathcal{V} has an n -ary Taylor term for some n .
- 4 (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x,$$

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014)

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014)

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term.

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x,$$

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

- ⑥ (Olšák, 2017)

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

- ⑥ (Olšák, 2017)

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

- ⑥ (Olšák, 2017) \mathcal{V} has a 6-ary Olšák term.

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

- ⑥ (Olšák, 2017) \mathcal{V} has a 6-ary Olšák term. \mathcal{V} satisfies

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

- ⑥ (Olšák, 2017) \mathcal{V} has a 6-ary Olšák term. \mathcal{V} satisfies

$$O(x, x, x, x, x, x) \approx x,$$

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

- ⑥ (Olšák, 2017) \mathcal{V} has a 6-ary Olšák term. \mathcal{V} satisfies

$$O(x, x, x, x, x, x) \approx x, \quad O(x, y, y, y, x, x) \approx O(y, x, y, x, y) \approx O(y, y, x, x, x, y).$$

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

- ⑥ (Olšák, 2017) \mathcal{V} has a 6-ary Olšák term. \mathcal{V} satisfies

$$O(x, x, x, x, x, x) \approx x, \quad O(x, y, y, y, x, x) \approx O(y, x, y, x, y) \approx O(y, y, x, x, x, y).$$

- ⑦ \mathcal{V} has a weak difference term.

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

- ⑥ (Olšák, 2017) \mathcal{V} has a 6-ary Olšák term. \mathcal{V} satisfies

$$O(x, x, x, x, x, x) \approx x, \quad O(x, y, y, y, x, x) \approx O(y, x, y, x, y) \approx O(y, y, x, x, x, y).$$

- ⑦ \mathcal{V} has a weak difference term.

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

- ⑥ (Olšák, 2017) \mathcal{V} has a 6-ary Olšák term. \mathcal{V} satisfies

$$O(x, x, x, x, x, x) \approx x, \quad O(x, y, y, y, x, x) \approx O(y, x, y, x, y) \approx O(y, y, x, x, x, y).$$

- ⑦ \mathcal{V} has a weak difference term. (This is a term $w(x, y, z)$ that is a Maltsev operation on the block of any abelian congruence.)

A characterization theorem

Theorem. The following are equivalent for a locally finite variety \mathcal{V} .

- ① \mathcal{V} omits type **1**.
- ② \mathcal{V} satisfies some nontrivial idempotent Maltsev condition.
- ③ \mathcal{V} has an n -ary Taylor term for some n .
- ④ (Siggers, 2010) \mathcal{V} has a 6-ary Siggers term. \mathcal{V} satisfies

$$S(x, x, x, x, x, x) \approx x, \quad S(x, x, y, y, z, z) \approx S(y, z, x, z, x, y).$$

- ⑤ (Kearnes-Markovic-McKenzie, 2014) \mathcal{V} has a 4-ary Rare Area term. \mathcal{V} satisfies

$$t(x, x, x, x) \approx x, \quad t(r, a, r, e) \approx t(a, r, e, a).$$

- ⑥ (Olšák, 2017) \mathcal{V} has a 6-ary Olšák term. \mathcal{V} satisfies

$$O(x, x, x, x, x, x) \approx x, \quad O(x, y, y, y, x, x) \approx O(y, x, y, x, y) \approx O(y, y, x, x, x, y).$$

- ⑦ \mathcal{V} has a weak difference term. (This is a term $w(x, y, z)$ that is a Maltsev operation on the block of any abelian congruence.)
- ⑧ Congruence lattices of algebras in \mathcal{V} lie in $\text{SD}_{\wedge}/\text{Modular}$.

Some examples

Some examples

- ① If \mathcal{V} has an underlying semilattice term $x \wedge y$, then $t(w, x, y, z) = w \wedge x$ is a Rare Area term for \mathcal{V} .

Some examples

- ① If \mathcal{V} has an underlying semilattice term $x \wedge y$, then $t(w, x, y, z) = w \wedge x$ is a Rare Area term for \mathcal{V} .

Some examples

- ① If \mathcal{V} has an underlying semilattice term $x \wedge y$, then $t(w, x, y, z) = w \wedge x$ is a Rare Area term for \mathcal{V} .
(Need to check idempotence $x \wedge x \approx x$)

Some examples

- ① If \mathcal{V} has an underlying semilattice term $x \wedge y$, then $t(w, x, y, z) = w \wedge x$ is a Rare Area term for \mathcal{V} .
(Need to check idempotence $x \wedge x \approx x$ and $t(r, a, r, e) \approx t(a, r, e, a)$):

Some examples

- ① If \mathcal{V} has an underlying semilattice term $x \wedge y$, then $t(w, x, y, z) = w \wedge x$ is a Rare Area term for \mathcal{V} .
(Need to check idempotence $x \wedge x \approx x$ and $t(r, a, r, e) \approx t(a, r, e, a)$: $w \wedge x \approx x \wedge w$.)

Some examples

- ① If \mathcal{V} has an underlying semilattice term $x \wedge y$, then

$t(w, x, y, z) = w \wedge x$ is a Rare Area term for \mathcal{V} .

(Need to check idempotence $x \wedge x \approx x$ and

$t(r, a, r, e) \approx t(a, r, e, a)$: $w \wedge x \approx x \wedge w$.)

(In fact, this construction shows that any locally finite variety that has an idempotent, commutative, binary term operation must omit type **1**.)

Some examples

- 1 If \mathcal{V} has an underlying semilattice term $x \wedge y$, then

$t(w, x, y, z) = w \wedge x$ is a Rare Area term for \mathcal{V} .

(Need to check idempotence $x \wedge x \approx x$ and

$t(r, a, r, e) \approx t(a, r, e, a)$: $w \wedge x \approx x \wedge w$.)

(In fact, this construction shows that any locally finite variety that has an idempotent, commutative, binary term operation must omit type 1.)

- 2 If \mathcal{V} has a Maltsev term $M(x, y, z)$, then

$t(w, x, y, z) = M(y, w, z)$ is a Rare Area term for \mathcal{V} .

Some examples

- 1 If \mathcal{V} has an underlying semilattice term $x \wedge y$, then

$t(w, x, y, z) = w \wedge x$ is a Rare Area term for \mathcal{V} .

(Need to check idempotence $x \wedge x \approx x$ and

$t(r, a, r, e) \approx t(a, r, e, a)$: $w \wedge x \approx x \wedge w$.)

(In fact, this construction shows that any locally finite variety that has an idempotent, commutative, binary term operation must omit type 1.)

- 2 If \mathcal{V} has a Maltsev term $M(x, y, z)$, then

$t(w, x, y, z) = M(y, w, z)$ is a Rare Area term for \mathcal{V} .

Some examples

- ① If \mathcal{V} has an underlying semilattice term $x \wedge y$, then

$t(w, x, y, z) = w \wedge x$ is a Rare Area term for \mathcal{V} .

(Need to check idempotence $x \wedge x \approx x$ and

$t(r, a, r, e) \approx t(a, r, e, a)$: $w \wedge x \approx x \wedge w$.)

(In fact, this construction shows that any locally finite variety that has an idempotent, commutative, binary term operation must omit type 1.)

- ② If \mathcal{V} has a Maltsev term $M(x, y, z)$, then

$t(w, x, y, z) = M(y, w, z)$ is a Rare Area term for \mathcal{V} .

(Need to check idempotence $M(x, x, x) \approx x$

Some examples

- ① If \mathcal{V} has an underlying semilattice term $x \wedge y$, then

$t(w, x, y, z) = w \wedge x$ is a Rare Area term for \mathcal{V} .

(Need to check idempotence $x \wedge x \approx x$ and

$t(r, a, r, e) \approx t(a, r, e, a)$: $w \wedge x \approx x \wedge w$.)

(In fact, this construction shows that any locally finite variety that has an idempotent, commutative, binary term operation must omit type 1.)

- ② If \mathcal{V} has a Maltsev term $M(x, y, z)$, then

$t(w, x, y, z) = M(y, w, z)$ is a Rare Area term for \mathcal{V} .

(Need to check idempotence $M(x, x, x) \approx x$ and

$t(r, a, r, e) \approx t(a, r, e, a)$:

Some examples

- ① If \mathcal{V} has an underlying semilattice term $x \wedge y$, then

$t(w, x, y, z) = w \wedge x$ is a Rare Area term for \mathcal{V} .

(Need to check idempotence $x \wedge x \approx x$ and

$t(r, a, r, e) \approx t(a, r, e, a)$: $w \wedge x \approx x \wedge w$.)

(In fact, this construction shows that any locally finite variety that has an idempotent, commutative, binary term operation must omit type 1.)

- ② If \mathcal{V} has a Maltsev term $M(x, y, z)$, then

$t(w, x, y, z) = M(y, w, z)$ is a Rare Area term for \mathcal{V} .

(Need to check idempotence $M(x, x, x) \approx x$ and

$t(r, a, r, e) \approx t(a, r, e, a)$: $M(r, r, e) \approx M(e, a, a)$.)

Completing a theme

Completing a theme

For each principal pair of order ideals $I \subseteq J$ in the poset of types (EXCEPT ONE),

Completing a theme

For each principal pair of order ideals $I \subseteq J$ in the poset of types (EXCEPT ONE), we know the idempotent Maltsev condition which characterizes the following property:

Completing a theme

For each principal pair of order ideals $I \subseteq J$ in the poset of types (EXCEPT ONE), we know the idempotent Maltsev condition which characterizes the following property:

Locally finite \mathcal{V} omits minimal sets for the types in I and omits the tails for minimal sets for the types in J .

Completing a theme

For each principal pair of order ideals $I \subseteq J$ in the poset of types (EXCEPT ONE), we know the idempotent Maltsev condition which characterizes the following property:

Locally finite \mathcal{V} omits minimal sets for the types in I and omits the tails for minimal sets for the types in J .

The missing case is $I = \{1, 5\}$ and $J = \{1, 4, 5\}$.

Completing a theme

For each principal pair of order ideals $I \subseteq J$ in the poset of types (EXCEPT ONE), we know the idempotent Maltsev condition which characterizes the following property:

Locally finite \mathcal{V} omits minimal sets for the types in I and omits the tails for minimal sets for the types in J .

The missing case is $I = \{1, 5\}$ and $J = \{1, 4, 5\}$.

Question.

Completing a theme

For each principal pair of order ideals $I \subseteq J$ in the poset of types (EXCEPT ONE), we know the idempotent Maltsev condition which characterizes the following property:

Locally finite \mathcal{V} omits minimal sets for the types in I and omits the tails for minimal sets for the types in J .

The missing case is $I = \{1, 5\}$ and $J = \{1, 4, 5\}$.

Question. What is the associated Maltsev condition? Does the class of varieties that satisfy it have interesting properties?

Completing a theme

For each principal pair of order ideals $I \subseteq J$ in the poset of types (EXCEPT ONE), we know the idempotent Maltsev condition which characterizes the following property:

Locally finite \mathcal{V} omits minimal sets for the types in I and omits the tails for minimal sets for the types in J .

The missing case is $I = \{1, 5\}$ and $J = \{1, 4, 5\}$.

Question. What is the associated Maltsev condition? Does the class of varieties that satisfy it have interesting properties?