

Intégration et analyse non standard*

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1 La théorie des ensembles internes de Nelson

La version, due à Nelson [13], de l'analyse non standard [16], consiste à rajouter au prédicat binaire \in et aux axiomes de Zermelo-Fraenkel de la théorie des ensembles (ZFC), base des mathématiques classiques, un prédicat unaire *standard*, noté *st*, et trois axiomes supplémentaires régissant son mode d'emploi : l'axiome de transfert (T), l'axiome d'idéalisation (I) et l'axiome de standardisation (S) ([13, 5, 6]). On obtient ainsi la *théorie des ensembles internes* (IST).

Par rapport à ZFC (dans laquelle, rappelons-le, tous les objets mathématiques sont des ensembles), la nouvelle théorie permet une distinction nouvelle entre *ensembles standard* et *ensembles non standard*. Comme c'est le cas pour ZFC, les formules de la théorie IST sont écrites, à partir des symboles de la logique formelle et des prédicats \in et *st*, en respectant les règles syntaxiques usuelles, et des constantes (comme \emptyset pour l'ensemble vide, \mathbb{N} pour l'ensemble des naturels,...) sont introduites pour remplacer de longues formules définissant univoquement des ensembles souvent utilisés. De telles constantes seront appelées *standard* si leur définition n'implique pas le prédicat *st* et *non standard* sinon. Bien entendu, toutes les constantes de la mathématique classique (ZFC) sont standard (en particulier, 5, 32.000, π , \mathbb{N} , \mathbb{R} sont standard). Une formule sera dite *interne* si elle peut s'écrire sans utiliser le mot *standard* ni aucun de ses dérivés. Une formule interne sera dite *standard* si toutes les constantes de cette formule sont standard.

L'axiome de transfert affirme que pour toute formule standard

$$S(x, t_1, \dots, t_n)$$

n'ayant pas d'autres variables libres que x, t_1, \dots, t_n , on a l'énoncé suivant:

$$\forall^{st} t_1, t_2, \dots, t_n \left[\forall^{st} x \Rightarrow \forall x S(x, t_1, \dots, t_n) \right],$$

ou encore l'énoncé équivalent

$$\forall^{st} t_1, t_2, \dots, t_n \left[\exists x \Rightarrow \exists^{st} x S(x, t_1, \dots, t_n) \right].$$

*Méthodes et analyse non standard, A. Pétry ed., Cahiers du Centre de Logique, vol. 9, Academia, Louvain-la-Neuve, 1996, 9-23.

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