

List of axioms and axiom systems

oldalszámokat
ellenőrizni!

Convention: In this list the axiom systems (i.e. theories) to be recalled will be boxed in. The only purpose of this is to make searching in the list easier.

(1) Main axiom systems

Basax $\stackrel{\text{def}}{=} \{ \mathbf{Ax1}, \mathbf{Ax2}, \mathbf{Ax3}, \mathbf{Ax4}, \mathbf{Ax5}, \mathbf{Ax6}, \mathbf{AxE} \}$ (cf. p.51), where:

Ax1 $G = \text{Eucl}(n, \mathbf{F})$, p.45.

Ax2 $\text{Obs} \cup \text{Ph} \subseteq \text{Ib}$, p.48.

Ax3 $(\forall h \in \text{Ib})(\forall m \in \text{Obs}) \text{tr}_m(h) \in G$, p.48.

Ax4 $(\forall m \in \text{Obs}) \text{tr}_m(m) = \bar{t}$, p.48.

Ax5 $(\forall m \in \text{Obs})(\forall \ell \in G) \left(\text{ang}^2(\ell) < 1 \Rightarrow (\exists k \in \text{Obs}) \ell = \text{tr}_m(k) \text{ and} \right.$
 $\left. \text{ang}^2(\ell) = 1 \Rightarrow (\exists ph \in \text{Ph}) \ell = \text{tr}_m(ph) \right)$, p.50.

Ax6 $(\forall m, k \in \text{Obs}) \text{Rng}(w_m) = \text{Rng}(w_k)$, p.50.

AxE $(\forall m \in \text{Obs})(\forall ph \in \text{Ph}) v_m(ph) = 1$, p.51.

Newbasax $\stackrel{\text{def}}{=} (\mathbf{Basax} \setminus \{ \mathbf{Ax6}, \mathbf{Ax3}, \mathbf{AxE} \}) \cup \{ \mathbf{Ax6}_{00}, \mathbf{Ax6}_{01}, \mathbf{Ax3}_0, \mathbf{AxE}_0 \} =$
 $\{ \mathbf{Ax1}, \mathbf{Ax2}, \mathbf{Ax3}_0, \mathbf{Ax4}, \mathbf{Ax5}, \mathbf{Ax6}_{00}, \mathbf{Ax6}_{01}, \mathbf{AxE}_0 \}$ (cf. p.191), where:

Ax6₀₀ $(\forall m, k \in \text{Obs}) w_m[\text{tr}_m(k)] \subseteq \text{Rng}(w_k)$, p.190.

Intuitively, observer k sees all those events which are seen by another observer m on k 's life-line.

Ax6₀₁ $(\forall m, k \in \text{Obs}) \text{Dom}(f_{mk}) \in \text{Open}$, p.190.

Ax3₀ $(\forall h \in \text{Ib}) (\text{tr}_m(h) \in G \cup \{ \emptyset \} \wedge (\exists k \in \text{Obs}) \text{tr}_k(h) \neq \emptyset)$, p.191.

AxE₀ $(\forall m \in \text{Obs})(\forall ph \in \text{Ph})(\text{tr}_m(ph) \neq \emptyset \Rightarrow v_m(ph) = 1)$, p.191.

$\boxed{\mathbf{Bax}}$ $\stackrel{\text{def}}{=} (\mathbf{Newbasax} \setminus \{ \mathbf{Ax5}, \mathbf{AxE}_0 \}) \cup \{ \mathbf{Ax5}^{\text{Obs}}, \mathbf{Ax5}^{\text{Ph}}, \mathbf{AxE}_{00}, \mathbf{AxE}_{01} \} = \{ \mathbf{Ax1}, \mathbf{Ax2}, \mathbf{Ax3}_0, \mathbf{Ax4}, \mathbf{Ax5}^{\text{Obs}}, \mathbf{Ax5}^{\text{Ph}}, \mathbf{Ax6}_{00}, \mathbf{Ax6}_{01}, \mathbf{AxE}_{00}, \mathbf{AxE}_{01} \}$ (cf. p.219), where:

$\mathbf{Ax5}^{\text{Obs}}$ $(\exists ph)(\forall \ell) \left(m \overset{\circ}{\rightarrow} ph \wedge [ang^2(\ell) < v_m(ph) \Rightarrow (\exists k)\ell = tr_m(k)] \right)$, p.218

$\mathbf{Ax5}^{\text{Ph}}$ $ang^2(\ell) = v_m(ph) \Rightarrow (\exists ph)\ell = tr_m(ph)$, p.219.

\mathbf{AxE}_{00} $(m \overset{\circ}{\rightarrow} ph_1, ph_2) \Rightarrow v_m(ph_1) = v_m(ph_2)$, p.218.

\mathbf{AxE}_{01} $v_m(ph) \neq 0$, p.218.

$\boxed{\mathbf{Flxbasax}}$ $\stackrel{\text{def}}{=} \mathbf{Bax} + \mathbf{AxE}_{02} = \{ \mathbf{Ax1}, \mathbf{Ax2}, \mathbf{Ax3}_0, \mathbf{Ax4}, \mathbf{Ax5}^{\text{Obs}}, \mathbf{Ax5}^{\text{Ph}}, \mathbf{Ax6}_{00}, \mathbf{Ax6}_{01}, \mathbf{AxE}_{00}, \mathbf{AxE}_{01}, \mathbf{AxE}_{02} \}$ (cf. p.428), where:

\mathbf{AxE}_{02} $(\forall m, k \in \text{Obs})(\forall ph, ph_1 \in \text{Ph})$
 $[(m \overset{\circ}{\rightarrow} ph \wedge k \overset{\circ}{\rightarrow} ph_1) \Rightarrow v_m(ph) = v_k(ph_1)]$, p.427.

$\boxed{\mathbf{Bax}^-}$ $\stackrel{\text{def}}{=} (\mathbf{Bax} \setminus \{ \mathbf{Ax5}^{\text{Obs}}, \mathbf{Ax5}^{\text{Ph}}, \mathbf{AxE}_{00} \}) \cup \{ \mathbf{Ax5}_{\text{Obs}}, \mathbf{Ax5}_{\text{Ph}}, \mathbf{AxP1} \} = \{ \mathbf{Ax1}, \mathbf{Ax2}, \mathbf{Ax3}_0, \mathbf{Ax4}, \mathbf{Ax5}_{\text{Obs}}, \mathbf{Ax5}_{\text{Ph}}, \mathbf{Ax6}_{00}, \mathbf{Ax6}_{01}, \mathbf{AxP1}, \mathbf{AxE}_{01} \}$ (cf. p.479), where:

$\mathbf{AxP1}$ Intuitively, starting out from one point p of space-time, in every direction (forwards) there is at most one “speed of light” (i.e. photon-trace), formally:

$(\forall m \in \text{Obs})(\forall ph_1, ph_2 \in \text{Ph})(\forall d \in \text{directions})^{1298} \left((ph_1 \text{ and } ph_2 \text{ are moving forwards in direction } d \text{ as seen by } m \text{ and } tr_m(ph_1) \cap tr_m(ph_2) \neq \emptyset) \Rightarrow tr_m(ph_1) = tr_m(ph_2) \right)$, p.472.

$\mathbf{Ax5}_{\text{Ph}}$ Intuitively, from any point p of space-time in any direction there is a photon moving forwards in that direction, cf. Fig.138 (p.477), formally:

$(\forall m \in \text{Obs})(\forall p \in {}^n F)(\forall d \in \text{directions})(\exists ph \in \text{Ph})$
 $[p \in tr_m(ph) \wedge (ph \text{ is moving forwards in direction } d \text{ as seen by } m)]$, p.477.

¹²⁹⁸Let us recall that directions are (nonzero) space-vectors, i.e. $\text{directions} = {}^{n-1}F \setminus \{\bar{0}\}$, cf. p.470.

Ax5_{Obs} Intuitively: Let us fix an observer m , a direction d , and a point p of space-time. We will speak about things moving forwards in direction d through point p as seen by m (without mentioning all this data). Assume there is a photon moving in direction d . Then there is a photon in the same direction which is limiting in the following sense: For all speeds slower than this limiting photon, there is an observer moving with this speed, cf. Fig.139 (p.478). Formally:

$$\begin{aligned}
 & (\forall m \in Obs)(\forall p \in {}^nF)(\forall d \in \text{directions}) \\
 & \left(\left[(\exists ph \in Ph)(p \in tr_m(ph) \wedge (ph \text{ is moving forwards in } d \text{ as seen by } m)) \right] \Rightarrow \right. \\
 & \left. \left[(\exists ph \in Ph) \left(p \in tr_m(ph) \wedge (ph \text{ is moving forwards in } d \text{ as seen by } m) \wedge \right. \right. \right. \\
 & \left. \left. \left. (\forall \lambda \in F)(0 \leq \lambda < v_m(ph) \Rightarrow (\exists k \in Obs)(p \in tr_m(k) \wedge v_m(k) = \lambda \wedge \right. \right. \right. \\
 & \left. \left. \left. (k \text{ is moving forwards in direction } d \text{ as seen by } m)) \right) \right] \right] \right), \text{ p.477.}
 \end{aligned}$$

Pax $\stackrel{\text{def}}{=} \{ \mathbf{Ax1}, \mathbf{Ax2}, \mathbf{Ax3}_0, \mathbf{Ax4}, \mathbf{Ax5}_{Obs}^{--}, \mathbf{Ax6}_{00}, \mathbf{Ax6}_{01} \}$ (cf. p.482) where:

Ax1, Ax2, Ax3₀, Ax4, Ax6₀₀, Ax6₀₁ have already been listed.

Ax5_{Obs}⁻⁻ Intuitively, for each direction d there is a positive λ such that through any point there are observers moving forwards in direction d with all speeds smaller than λ . More precisely, for any observer m and for any plane P parallel with \bar{t} there is $\lambda \in {}^+F$ such that for any straight line ℓ in P , with $ang^2(\ell) < \lambda$, ℓ is the trace of an observer (as seen by m , of course). In other words:

$$\begin{aligned}
 & (\forall m \in Obs)(\forall d \in \text{directions})(\forall p \in {}^nF)(\exists \lambda \in {}^+F) \\
 & (\forall q \in {}^nF) \left[\text{space}(p) - \text{space}(q) = \delta \cdot d \text{ for some } \delta \in F \Rightarrow (\forall 0 \leq \varepsilon < \lambda) \right. \\
 & \left. (\exists k \in Obs)(k \text{ moves forwards in direction } d \text{ with speed } \varepsilon \text{ and } q \in tr_m(k)) \right], \\
 & \text{p.481.}
 \end{aligned}$$

* * *

Assume **Ax1, Ax2, Ax3₀, AxP1**. Let $m \in Obs$. Then

$$c_m : {}^nF \times \text{directions} \xrightarrow{\circ} F \cup \{\infty\}$$

is a partial function such that $c_m(p, d)$ is defined iff m sees a photon at point p moving forwards in direction d , and $c_m(p, d)$ is the speed of this photon,¹²⁹⁹ cf. pp. 473, 535.

¹²⁹⁹There is only one such speed because of **AxP1**.

§4-ben is ki-javítani az intuitív szöveget! esetleg a formulában is P síkot használni!

Let Th be one of our theories such that $Th \models \{ \mathbf{Ax1}, \mathbf{Ax2}, \mathbf{Ax3}_0, \mathbf{AxP1} \}$. Then

$$\boxed{Th^\oplus} \stackrel{\text{def}}{=} Th + c_m(p, d) < \infty, \text{ p.643.}$$

Next, we turn to listing the Reichenbachian versions of our theories. For this we recall some notation.

Assume \mathbf{Bax}^- . By Thm.4.3.17 (p.488), the speed $c_m(p, d)$ does not depend on p . This motivates the following:

$$c_m(d) \stackrel{\text{def}}{=} c_m(\bar{0}, d),$$

cf. p.488. Intuitively, $c_m(d)$ is the (square of the) speed of light in direction d as seen by observer m .

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speed of light?

Notation: Let $m \in Obs$ and $d \in directions$. Then

$$T_m(d) \stackrel{\text{def}}{=} \begin{cases} 1/\sqrt{c_m(d)} & \text{if } 0 \neq c_m(d) < \infty, \\ \infty & \text{if } c_m(d) = 0, \\ 0 & \text{if } c_m(d) = \infty, \end{cases}$$

cf. p.555. $T_m(d)$ is the reciprocal of the “speed of light”, i.e. it is the time needed for a photon to cover the unit distance in direction d (as seen by observer m).

$$\boxed{\mathbf{Reich}_0(\mathbf{Bax})} \stackrel{\text{def}}{=} \mathbf{Bax}^- + \mathbf{R}(\mathbf{AxE}_{00}) \text{ (cf. p.562), where}$$

$$\mathbf{R}(\mathbf{AxE}_{00}) \text{ } \mathbf{Ax}(\sqrt{\quad}) \text{ and} \\ (\forall d, d_1 \in directions)[T_m(d) + T_m(-d) = T_m(d_1) + T_m(-d_1)], \text{ p.557.}$$

$$\boxed{\mathbf{Reich}_0(\mathbf{Flxbasax})} \stackrel{\text{def}}{=} \mathbf{Bax}^- + \mathbf{R}(\mathbf{AxE}_{02}) \text{ (cf. p.562), where}$$

$$\mathbf{R}(\mathbf{AxE}_{02}) \text{ } (\forall m, k \in Obs)(\forall d, d_1 \in directions) \\ T_m(d) + T_m(-d) = T_k(d_1) + T_k(-d_1), \text{ and } \mathbf{Ax}(\sqrt{\quad}), \text{ p.557.}$$

$$\boxed{\mathbf{Reich}_0(\mathbf{Newbasax})} \stackrel{\text{def}}{=} \mathbf{Bax}^- + \mathbf{R}(\mathbf{AxE}) \text{ (cf. p.562), where}$$

$$\mathbf{R}(\mathbf{AxE}) \text{ } \mathbf{Ax}(\sqrt{\quad}) \text{ and} \\ (\forall m \in Obs)(\forall d \in directions)T_m(d) + T_m(-d) = 2, \text{ p.557.}$$

$$\boxed{\mathbf{Reich}_0(\mathbf{Basax})} \stackrel{\text{def}}{=} \mathbf{Reich}_0(\mathbf{Newbasax}) + \mathbf{Ax6}, \text{ p.562.}$$

Let $Th \in \{ \mathbf{Bax}, \mathbf{Flxbasax}, \mathbf{Newbasax}, \mathbf{Basax} \}$. Then

$$\boxed{\mathbf{Reich}(Th)} \stackrel{\text{def}}{=} \mathbf{Reich}_0(Th) + \mathbf{R}_\Delta(E) \text{ (cf. p.576), where}$$

$$\mathbf{R}_\Delta(E) \quad (\forall m \in \text{Obs})(\exists r \in F)(\forall d_1, d_2, d_3 \in \text{directions}) \left[d_1 + d_2 + d_3 = \bar{0} \Rightarrow \frac{|d_1| \cdot T_m(d_1) + |d_2| \cdot T_m(d_2) + |d_3| \cdot T_m(d_3)}{|d_1| + |d_2| + |d_3|} = r \right], \text{ p.574.}$$

(2) Axioms concerning the direction of flow of time

The binary relation $\uparrow \subseteq \text{Obs} \times \text{Obs}$ is defined as follows.

$$m \uparrow k \stackrel{\text{def}}{\iff} (\mathbf{f}_{km}(1_t)_t - \mathbf{f}_{km}(\bar{0})_t > 0), \text{ p.296.}$$

Intuitively, $m \uparrow k$ means that m sees k 's clock running forwards. Further, if $m, k \in \text{Obs}$ then $m \text{ STL } k$ means that m sees k moving slower than light (cf. Def.4.2.6 on p.460).

$$\mathbf{Ax}(\uparrow) \quad (\forall m, m' \in \text{Obs}) (tr_m(m') = \bar{t} \Rightarrow m \uparrow m'), \text{ p.296.}$$

$$\mathbf{Ax}(\uparrow\uparrow) \quad (\forall m, k \in \text{Obs}) m \uparrow k, \text{ p.426.}$$

$$\mathbf{Ax}(\uparrow\uparrow_0) \quad (\forall m, k \in \text{Obs}) (m \overset{\circ}{\rightarrow} k \rightarrow m \uparrow k), \text{ p.840.}$$

$$\mathbf{Ax}(\uparrow\uparrow_{00}) \quad (\forall m, k \in \text{Obs}) (m \text{ STL } k \rightarrow m \uparrow k), \text{ p.840.}$$

(3) Auxiliary axioms

Recall that

$$\text{Triv} = \{ f : f \text{ is an isometry of } {}^n\mathbf{F} \text{ and } f(1_t) - f(\bar{0}) = 1_t \},$$

cf. p.135.

$$\mathbf{Ax}(\text{Triv}) \quad (\forall m \in \text{Obs})(\forall f \in \text{Triv})(\exists k \in \text{Obs}) \mathbf{f}_{mk} = f, \text{ p.135.}$$

$$\mathbf{Ax}(\text{Triv}_t) \quad (\forall m \in \text{Obs})(\forall f \in \text{Triv}) \left(f[\bar{t}] = \bar{t} \Rightarrow (\exists k \in \text{Obs}) \mathbf{f}_{mk} = f \right), \text{ p.135.}$$

$\mathbf{Ax}(\text{Triv}_t)^-$ Assume we are given an observer m and a Triv transformation f that leaves the time-axis fixed. Then m has a brother, call it k , such that m thinks that (i) the coordinate axes of k are the f -images of the original coordinate axes \bar{x}_i , and (ii) the clock of k runs forwards, formally:

$$(\forall m \in \text{Obs})(\forall f \in \text{Triv}) [f[\bar{t}] = \bar{t} \Rightarrow (\exists k \in \text{Obs})(\forall i \in n)(\mathbf{f}_{km}[\bar{x}_i] = f[\bar{x}_i] \wedge m \uparrow k)], \text{ p.812.}$$

Ax(||) $(\forall m, k \in Obs) (tr_m(k) \parallel \bar{t} \Rightarrow (f_{mk} \text{ is an isometry}))$, p.136.

Ax(||)⁻ $(\forall m, k \in Obs \cap Ib)$
 $[tr_m(k) = \bar{t} \Rightarrow (f_{mk} = h \circ I, \text{ for some expansion } h \text{ and isometry } I)]$,
p.828.

Ax($\sqrt{\quad}$) $(\forall 0 < x \in F)(\exists y \in F) y^2 = x$, p.91.

Ax(rc) (Axiom schema for real-closed fields)

Ax($\sqrt{\quad}$) + $\{ \phi_{2n+1} : n \in \omega \}$, where

$(\phi_n) \quad \forall x_0 \dots \forall x_n \exists y [x_n \neq 0 \rightarrow (x_0 + x_1 \cdot y + \dots + x_n \cdot y^n = 0)]$,

p.301.

Ax(diswind) (Axiom of disjoint windows)

$(\forall m, k \in Obs \cap Ib) [(m \overset{\circ}{\rightarrow} ph \wedge k \overset{\circ}{\rightarrow} ph) \Rightarrow m \overset{\circ}{\rightarrow} k]$, p.812.

(4) Axioms concerning measuring distances

Ax(eqtime) Observers with common life-line agree on time-like distances, i.e.

$(\forall m, m' \in Obs)$
 $(tr_m(m') = \bar{t} \Rightarrow (\forall p, q \in \bar{t}) |p - q| = |f_{mm'}(p) - f_{mm'}(q)|)$, p.127.

Ax(eqspace) Observers agree on spatial distances, i.e.

$(\forall m, k \in Obs)(\forall p, q \in {}^n F)$
 $(p_t = q_t \wedge f_{mk}(p)_t = f_{mk}(q)_t) \Rightarrow |p - q| = |f_{mk}(p) - f_{mk}(q)|$,
p.136.

Ax(eqm) Inertial observers agree on distances, i.e.

$(\forall m, k \in Obs \cap Ib)(\forall i, j \in n)(\forall p, q \in \bar{x}_i)(\forall p', q' \in \bar{x}_j)$
 $([w_m(p) = w_k(p') \wedge w_m(q) = w_k(q')] \Rightarrow |p - q| = |p' - q'|)$, p.796.

(5) Axiom systems Pax⁺, Pax⁺⁺, Pax₊⁺, Pax₊⁺⁺, Wax, Wax⁺

Ax(Bw) $(\forall m, k \in Obs)[m \stackrel{\circ}{\rightarrow} k \Rightarrow (f_{mk} \text{ is betweenness preserving})]$, p.1028.

Ax♡ $B = Obs \cup Ph$, p.296.

Ax(∞ph) $(\forall m \in Obs)(\forall ph, ph' \in Ph) \left([\bar{0} \in tr_m(ph) \cap tr_m(ph')] \wedge (ph \text{ and } ph' \text{ move in the same direction as seen by } m) \wedge v_m(ph) = \infty \right] \rightarrow v_m(ph') = \infty \right)$, p.1028.

sorrend?

Intuitively, no observer can emit simultaneously in the same direction two photons one with infinite speed and the other one with finite speed.

Ax(ext) $(\forall m, k \in Obs) [w_m = w_k \Rightarrow m = k] \wedge (\forall b, b_1 \in B \setminus Obs)(\forall m \in Obs) [tr_m(b) = tr_m(b_1) \Rightarrow b = b_1]$, p.298.

Ax(Ph) $(\forall m \in Obs)(\forall p \in {}^nF)(\exists ph_1, ph_2 \in Ph) tr_m(ph_1) \cap tr_m(ph_2) = \{p\}$, p.1073.

Pax⁺ $\stackrel{\text{def}}{=} \text{Pax} + \text{Ax}E_{01} + \text{Ax}(\text{Bw}) + \text{Ax}(\infty ph) + \left([\text{Ax}(\text{eqtime}) \wedge (\forall m, k \in Obs)(\forall 0 < i \in \omega) tr_m(k) \neq \bar{x}_i] \vee \text{Ax}(\text{eqm}) \right)$, p.1029.

Pax⁺⁺ $\stackrel{\text{def}}{=} \text{Pax}^+ + \text{Ax}(\text{eqm}) + \text{Ax}(\text{ext}) + \text{Ax}\heartsuit$, p.1081.

Pax₊⁺ $\stackrel{\text{def}}{=} \text{Pax}^+ + \text{Ax}(\text{diswind})$, p.1086.

Pax₊⁺⁺ $\stackrel{\text{def}}{=} \text{Pax}^{++} + \text{Ax}(\text{diswind})$, p.1093.

Wax $\stackrel{\text{def}}{=} \{ \text{Ax1}, \text{Ax2}, \text{Ax3}, \text{Ax4}, \text{Ax6}, \text{Ax}(\text{Bw}), \text{Ax}(Ph) \}$, p.1073.

Wax⁺ $\stackrel{\text{def}}{=} \text{Wax} + \text{Ax}(\text{ext}) + \text{Ax}\heartsuit + \text{Ax}(\infty ph) + (\forall m, k)(f_{mk} \in \text{Afr})$, p.1081.

(6) Symmetry axioms

Ax(symm₀) $(\forall m, k \in Obs)(\exists m', k' \in Obs)$
 $\left(tr_m(m') = tr_k(k') = \bar{t} \quad \wedge \quad f_{mk} = f_{k'm'} \right)$, p.124.

Ax(symm) is defined to be **Ax(symm₀)** + **Ax(eqtime)**, p.127.

Ax(syt₀) $(\forall m, k \in Obs) \left(tr_m(k) \neq \emptyset \Rightarrow \right.$
 $\left. (\forall p \in \bar{t}) |f_{mk}(p)_t - f_{mk}(\bar{0})_t| = |f_{km}(p)_t - f_{km}(\bar{0})_t| \right)$, p.134.

Ax(syt₀₀) $(\forall m, k \in Obs) [f_{mk}(\bar{0}) = \bar{0} \Rightarrow |f_{mk}(1_t)_t| = |f_{km}(1_t)_t|]$, p.138.

Ax(syt)* $f_{mk}(\bar{0}) = \bar{0} \Rightarrow f_{mk}(1_t)_t = f_{km}(1_t)_t$, p.721.

Ax(syx)* $(m, k \text{ are in pre-standard configuration}^{1300}) \Rightarrow |f_{mk}(1_x)_x| = |f_{km}(1_x)_x|$, p.725.

Ax(speedtime) $(\forall m, k, m', k' \in Obs) \left(v_m(k) = v_{m'}(k') \Rightarrow \right.$
 $\left. (\forall p \in \bar{t}) |f_{mk}(p)_t - f_{mk}(\bar{0})_t| = |f_{m'k'}(p)_t - f_{m'k'}(\bar{0})_t| \right)$, p.137.

Ax□1 $(\forall m, k, m' \in Obs)(\exists k' \in Obs) f_{mk} = f_{m'k'}$, p.350.

Ax□2 $(\forall m, k, m', k' \in Obs)(tr_m(k) = tr_{m'}(k') \rightarrow$
 there is an isometry N of ${}^n\mathbf{F}$ such that $N[\bar{t}] \parallel \bar{t}$ and $f_{mk} = f_{m'k'} \circ N$), p.350.

Ax△1 $(\forall m, k \in Obs)(\exists k' \in Obs)(tr_m(k) = tr_m(k') \wedge f_{mk'} = f_{k'm})$, p.351.

Ax△2 $(\forall m, k \in Obs)$ (there is an isometry N of ${}^n\mathbf{F}$ such that
 $N[\bar{t}] \parallel \bar{t}$ and $f_{mk} = N \circ f_{km} \circ N$), p.351.

Ax(ω)⁰ is defined to be the disjunction of the following symmetry axioms:
Ax(syt₀), **Ax(symm)**, **Ax(speedtime)**, **Ax△1**+**Ax(eqtime)**, **Ax△2**,
Ax□1+**Ax(eqtime)**, **Ax□2**, p.844.

Ax(ω)⁰⁰ is defined to be the disjunction of the following symmetry axioms: **Ax(ω)⁰**,
Ax(eqspace), **Ax(eqm)**+**Ax(Triv_t)⁻**, p.844.

Ax(ω)[#] is defined to be **Ax(ω)⁰**+**Ax(Triv_t)⁻**+**Ax($\sqrt{\quad}$)**, p.844.

¹³⁰⁰ m and k are said to be in *pre-standard configuration* iff $f_{mk}(\bar{0}) = \bar{0}$ and $f_{mk}[\text{Plane}(\bar{t}, \bar{x})] = \text{Plane}(\bar{t}, \bar{x})$. Cf. Def.4.6.5 (p.602) and Fig.201 (p.603).

$\mathbf{Ax}(\omega)^{\#}$ is defined to be $\mathbf{Ax}(\omega)^{00} + \mathbf{Ax}(Triv_t)^- + \mathbf{Ax}(\sqrt{\quad})$, p.844.

$\mathbf{Ax}(\mathbf{symm})^\dagger$ is defined to be $\mathbf{Ax}(\mathbf{symm}) + \mathbf{Ax}(Triv) + \mathbf{Ax}(\|)$, p.151.

$\mathbf{Ax}(\omega) \ \mathbf{Ax}\square 1 \wedge \mathbf{Ax}\square 2 \wedge \mathbf{Ax}\triangle 1 \wedge \mathbf{Ax}\triangle 2$, p.351.

$\mathbf{Ax}(\omega^-) \ \mathbf{Ax}\square 1 \vee \mathbf{Ax}\square 2 \vee \mathbf{Ax}\triangle 1 \vee \mathbf{Ax}\triangle 2$, p.351.

(7) Symmetry axioms adequate for Reichenbachian theories

$\mathbf{R}^+(\mathbf{Ax} \ \mathbf{eqsp})$ Intuitively, the thickness of spaceships do not change in the direction orthogonal to movement (cf. pp. 608–614), formally:

Assume $m, k \in Obs$ such that $m \overset{\circ}{\rightarrow} k$. Assume P, Q are parallel planes of nF such that they are parallel with both \bar{t} and $tr_m(k)$. Then

$$\begin{aligned} \text{Eudist}(P, Q) &= \text{Eudist}(f_{mk}[P], f_{mk}[Q]), \text{ p.614, where} \\ \text{Eudist}(H, H_1) &\stackrel{\text{def}}{=} \inf \{ \|p - q\| : p \in H \text{ and } q \in H_1 \}. \end{aligned}$$

$\mathbf{R}(\mathbf{Ax} \ \mathbf{eqsp})$ Intuitively, the thickness of spaceships do not change in the direction orthogonal to movement (cf. pp. 608–614), formally:

Assume m and k are in pre-standard configuration¹³⁰¹. Let P be a (2-dimensional) plane parallel with $\text{Plane}(\bar{t}, \bar{x})$. Then the distance between P and $\text{Plane}(\bar{t}, \bar{x})$ is the same as the distance between $f_{mk}[P]$ and $f_{mk}[\text{Plane}(\bar{t}, \bar{x})]$. Formally,

$$\begin{aligned} \text{Eudist}(P, \text{Plane}(\bar{t}, \bar{x})) &= \text{Eudist}(f_{mk}[P], f_{mk}[\text{Plane}(\bar{t}, \bar{x})]), \text{ p.611, where} \\ \text{Eudist}(H, H_1) &\stackrel{\text{def}}{=} \inf \{ \|p - q\| : p \in H \text{ and } q \in H_1 \}, \text{ cf. p.609.} \end{aligned}$$

See Fig.205 on p.611.

$\mathbf{R}(\mathbf{Ax} \ \mathbf{syt}_0)$ Intuitively m and k *literally* see, via photons, each other's clocks slowing down with the same rate, see Fig.207 (p.616), formally:

$$\begin{aligned} (\forall m, k \in Obs)[f_{mk}(\bar{0}) = \bar{0} \Rightarrow \\ (\forall p \in \bar{t}) |view_m(f_{km}(p))| = |view_k(f_{mk}(p))|] \text{ (cf. p.615),} \\ \text{where } view_m \stackrel{\text{def}}{=} \{ \langle p, q \rangle \in {}^nF \times \bar{t} : p_t \leq q_t \text{ and } (\exists ph \in Ph) p, q \in tr_m(ph) \}, \\ \text{cf. Fig.206 (p.615).} \end{aligned}$$

$\mathbf{R}(\mathbf{sym})$ is defined to be $\mathbf{R}(\mathbf{Ax} \ \mathbf{eqsp}) + \mathbf{R}(\mathbf{Ax} \ \mathbf{syt}_0)$, p.616.

¹³⁰¹Cf. footnote 1300 on p.1260 for the notion of a pre-standard configuration.

(8) Twin paradox

Let $m, k \in Obs$. Then m *STL* k means that m sees k moving slower than light, cf. Def.4.2.6 on p.460 for details.

$$\mathbf{Ax}(\mathbf{TwP}) (\forall m, k_1, k_2 \in Obs)(\forall p, q, r \in {}^nF) \\ \left([m \text{ STL } k_1 \wedge m \text{ STL } k_2 \wedge p_t < q_t < r_t \wedge \{p\} = tr_m(m) \cap tr_m(k_1) \wedge \{q\} = tr_m(k_1) \cap tr_m(k_2) \wedge \{r\} = tr_m(m) \cap tr_m(k_2)] \Rightarrow \right. \\ \left. |p_t - r_t| > |f_{mk_1}(p)_t - f_{mk_1}(q)_t| + |f_{mk_2}(q)_t - f_{mk_2}(r)_t| \right), \text{ p.460}$$

(cf. Fig.43 on p.141).

The *existential version* $\mathbf{Ax}(\exists\mathbf{TwP})$ of the twin paradox is defined as follows. First, let us notice that $\mathbf{Ax}(\mathbf{TwP})$ is a formula of the pattern

$$(\forall m \dots)(\forall p \dots) \left([\dots] \Rightarrow |\dots| > |\dots| \right).$$

Let ψ_1, ψ_2 be formulas such that $\mathbf{Ax}(\mathbf{TwP})$ is the formula

$$(\forall m, k_1, k_2 \in Obs)(\forall p, q, r \in {}^nF)(\psi_1 \Rightarrow \psi_2).$$

§4.2 $\mathbf{Ax}(\exists\mathbf{TwP})$

def-ját

kijavítani: $\forall p, q, r$ helyett $\exists p, q, r$ kellene hogy legyen.

Now we define $\mathbf{Ax}(\exists\mathbf{TwP})$ as follows.

$$\mathbf{Ax}(\exists\mathbf{TwP}) (\exists m, k_1, k_2 \in Obs)(\exists p, q, r \in {}^nF)[\psi_1 \wedge \psi_2], \text{ p.461.}$$

(9) Axiom systems Specrel, Flxspecrel, BaCo, Compl, NewtK⁻, NewtK

$$\boxed{\text{Specrel}} \stackrel{\text{def}}{=} \mathbf{Basax} + \mathbf{Ax}(\text{symm})^\dagger, \text{ p.151.}$$

$$\boxed{\text{Flxspecrel}} \stackrel{\text{def}}{=} \mathbf{Bax} + \mathbf{Ax6} + \mathbf{Ax}(\text{symm})^\dagger + \mathbf{AxE}_{02}, \text{ p.428.}$$

$$\boxed{\text{Compl}} \stackrel{\text{def}}{=} \{ \mathbf{Ax}(\text{symm}), \mathbf{Ax}\heartsuit, \mathbf{Ax}(\uparrow), \mathbf{Ax5}^+, \mathbf{Ax}(\text{ext}), \mathbf{Ax}(\text{Triv}_t) \} \text{ (cf. p.298),}$$

where

$$\mathbf{Ax5}^+ \quad \ell \in \text{SlowEucl} \quad \Rightarrow \quad (\exists k \in Obs) (\ell = tr_m(k) \wedge m \uparrow k), \text{ p.297.}$$

$$\boxed{\text{BaCo}} \stackrel{\text{def}}{=} \mathbf{Basax} + \mathbf{Compl}, \text{ p.298.}$$

$$\boxed{\text{NewtK}^-} \stackrel{\text{def}}{=} \mathbf{Bax} + \mathbf{Ax6} + \mathbf{Ax}(\text{symm})^\dagger + (\forall m \in Obs)c_m = \infty \text{ (cf. p.426), where}$$

c_m is the speed of light for observer m , assuming \mathbf{Bax} .

$$\boxed{\text{NewtK}} \stackrel{\text{def}}{=} \text{NewtK}^- + \mathbf{Ax}(\uparrow\uparrow) + \mathbf{Ax}\square\mathbf{1}, \text{ p.426.}$$

(10) Geometrical axioms and axiom systems

Axioms **A₀**–**A₄** and **P₁**, **P₂**, **Pa** below apply to geometries with reducts $\langle Mn; Bw \rangle$ or $\langle Mn; coll \rangle$. In the case of “ $\langle Mn; Bw \rangle$ ” $coll$ is a defined relation, cf. p.818. The new universe (or sort) *lines* is (explicitly) defined over $\langle Mn; coll \rangle$ on p.1037. For $H \subseteq Mn$, $Plane'(H)$ is intuitively the “ n -long closure of H under $coll$ ” (cf. Def.6.2.15 on p.819), where throughout n is the dimension of our geometry and $n \geq 2$.

A₀ $(\forall a, b, c \in Mn)[coll(a, b, c) \leftrightarrow (\exists \ell \in lines) a, b, c \in \ell]$, p.1038.

A₁ $(\forall a, b \in Mn)(a \neq b \rightarrow (\exists! \ell \in lines) a, b \in \ell)$, p.1038.

A₂ Intuitively, if H is a less than $n + 2$ element subset of Mn then the “ n -long closure” $Plane'(H)$ of H under $coll$ will be closed under $coll$, hence the plane $Plane(H)$ generated by H coincides with $Plane'(H)$ (cf. Def.6.2.15, p.819), formally:

$$(\forall H \subseteq Mn) \left((|H| \leq n+1 \wedge a, b \in Plane'(H) \wedge coll(a, b, c)) \rightarrow c \in Plane'(H) \right), \text{ p.1039.}$$

A₃ Intuitively, if $i \leq n$ and H is an $i + 1$ element independent subset¹³⁰² of Mn then there is exactly one i -dimensional plane¹³⁰³ that contains H , formally:

$$(\forall H, H' \subseteq Mn) \left((|H| = |H'| \leq n+1 \wedge (\text{both } H \text{ and } H' \text{ are independent}) \wedge H \subseteq Plane'(H')) \rightarrow Plane'(H) = Plane'(H') \right), \text{ p.1039.}$$

A₄ Mn is an n dimensional plane, p.1039.

In connection with axioms **P₁**, **P₂** below we note that the relation of parallelism \parallel on *lines* is defined the usual way in Def.6.6.19 on p.1039.

P₁ (Euclid’s axiom)

$$(\forall \ell \in lines)(\forall a \in Mn)(\exists! \ell' \in lines)(a \in \ell' \wedge \ell \parallel \ell'), \text{ p.1040.}$$

P₂ $(\ell \parallel \ell' \wedge \ell' \parallel \ell'') \rightarrow \ell \parallel \ell'', \text{ p.1040.}$

¹³⁰²Let $H \subseteq Mn$. H is called *independent* iff $(\forall e \in H) e \notin Plane'(H \setminus \{e\})$, cf. p.1039.

¹³⁰³Let $P \subseteq Mn$. P is called an i -dimensional iff there is an $i + 1$ element independent subset H of Mn such that $Plane'(H) = P$, where for the notion of an independent subset cf. footnote 1302. Cf. Def.6.6.18(ii) on p.1039.

$\boxed{\text{ag}}$ $\stackrel{\text{def}}{=} \{A_0, A_1, A_2, A_3, A_4, P_1, P_2\}$, p.1040. **ag** is the axiom system for affine geometries.

For $a, b, c, d \in Mn$, the abbreviation $\langle a, b \rangle \parallel \langle c, d \rangle$ means that $a \neq b$, $c \neq d$, and there are $\ell, \ell' \in \text{lines}$ such that $a, b \in \ell$, $c, d \in \ell'$ and $\ell \parallel \ell'$, cf. p.1042.

Pa (Pappus-Pascal property)

$$(\forall \ell, \ell' \in \text{lines})(\forall a, b, c \in \ell \setminus \ell')(\forall a', b', c' \in \ell' \setminus \ell)$$

$$[(\langle a, b' \rangle \parallel \langle a', b \rangle \wedge \langle a, c' \rangle \parallel \langle a', c \rangle) \rightarrow \langle b, c' \rangle \parallel \langle b', c \rangle],$$

see Fig.319, p.1042.

$\boxed{\text{pag}}$ $\stackrel{\text{def}}{=} \text{ag} + \text{Pa}$, p.1042. **pag** is the axiom system for Pappian affine geometries.

Axioms **B₁–B₃** below apply to geometries with reducts $\langle Mn; Bw \rangle$. (*coll* is a defined relation.)

B₁ $Bw(a, b, c) \rightarrow (a \neq b \neq c \neq a \wedge Bw(c, b, a) \wedge \neg Bw(b, a, c))$, p.1043.

B₂ $a \neq b \rightarrow (\exists c)Bw(a, b, c)$, p.1043.

B₃ (Pasch's Law)

Intuitively, if a line ℓ lies in the plane determined by a triangle abc , and passes between a and b but not through c , then ℓ passes between a and c , or between b and c , formally:

$$(\neg \text{coll}(a, b, c) \wedge \ell \subseteq \text{Plane}'(\{a, b, c\}) \wedge (\exists d \in \ell)Bw(a, d, b)) \rightarrow (\exists e \in \ell)(Bw(a, e, c) \vee Bw(b, e, c)), \text{ p.1043 (cf. Fig.320 on p.1044).}$$

$\boxed{\text{opag}}$ $\stackrel{\text{def}}{=} \text{pag} + \{B_1, B_2, B_3\}$, p.1044. **opag** is the axiom system for ordered Pappian affine geometries.

Axioms **L₁, ..., L₁₀** below apply to geometries with reducts

$$\langle Mn, L; L^T, L^{Ph}, L^S, \in, \prec, Bw, \perp_r, eq \rangle.$$

Further, *coll* is a defined relation and it is defined over $\langle Mn; Bw \rangle$, cf. p.818, and *lines* is the new sort first-order defined from *coll*.

L₁ $L \subseteq \text{lines}$, p.1071.

L₂ $(\forall a \in Mn)(\exists \ell, \ell' \in L^{Ph}) \ell \cap \ell' = \{a\}$, p.1071.

lopag $\stackrel{\text{def}}{=} \text{opag} + \mathbf{L}_1 + \mathbf{L}_2$, p.1071.

L₃ $([a \prec b \wedge (Bw(a, b, c) \vee Bw(a, c, b))] \rightarrow a \prec c) \wedge$
 $([a \prec b \wedge (Bw(c, a, b) \vee Bw(a, c, b))] \rightarrow c \prec b)$, p.1076.

L₄ Intuitively, eq is (very) symmetric, formally:
 $\langle a, b \rangle eq \langle c, d \rangle \rightarrow (\langle c, d \rangle eq \langle a, b \rangle \wedge \langle b, a \rangle eq \langle c, d \rangle \wedge \langle a, a \rangle eq \langle c, c \rangle)$,
p.1076.

L₅ eq is transitive, i.e.
 $(\langle a, b \rangle eq \langle c, d \rangle \wedge \langle c, d \rangle eq \langle e, f \rangle) \rightarrow \langle a, b \rangle eq \langle e, f \rangle$, p.1076.

L₆ (For the intuitive meaning of this axiom see Fig.326 on p.1076.)
 $(\forall \ell, \ell' \in L)(\forall o, e, e', a, a' \in Mn) ([\ell \cap \ell' = \{o\} \wedge e, a \in \ell \wedge e', a' \in \ell' \wedge$
 $\langle e, e' \rangle \parallel \langle a, a' \rangle \wedge \langle o, e \rangle eq \langle o, e' \rangle] \rightarrow \langle o, a \rangle eq \langle o, a' \rangle)$, p.1076.

L₇ (For the intuitive meaning of this axiom see Fig.327 on p.1077.)
 $(\forall \ell \in L^T \cup L^S)(\forall a, b, c, d, e, f \in Mn) [(a, b, c, d \in \ell \wedge$
 $\langle a, b \rangle \parallel \langle e, f \rangle \parallel \langle c, d \rangle \wedge \langle a, e \rangle \parallel \langle b, f \rangle \wedge \langle c, e \rangle \parallel \langle d, f \rangle) \rightarrow \langle a, b \rangle eq \langle c, d \rangle]$,
p.1076.

L₈ \perp_r is symmetric, i.e.
 $(\forall \ell, \ell' \in L) (\ell \perp_r \ell' \rightarrow \ell' \perp_r \ell)$, p.1076.

L₉ \perp_r is closed under parallelism, i.e.
 $(\forall \ell, \ell_1, \ell_2 \in L) [(\ell \perp_r \ell_1 \wedge \ell_1 \parallel \ell_2) \rightarrow \ell \perp_r \ell_2]$, p.1076.

L₁₀ \perp_r is closed under taking limits, p.1077.

lopag⁺ $\stackrel{\text{def}}{=} \text{lopag} + \mathbf{L}_3 + \mathbf{L}_4 + \mathbf{L}_5 + \mathbf{L}_6 + \mathbf{L}_7 + \mathbf{L}_8 + \mathbf{L}_9 + \mathbf{L}_{10}$, p.1081

(11) “Speed of light free” axiom systems for relativity
(axioms and axiom systems used in Chapter 5)

Relnoph₀ $\stackrel{\text{def}}{=} (\mathbf{Ax1-Ax4})^{1304} + \mathbf{Ax6} + \mathbf{Ax}\square\mathbf{1} + \mathbf{Ax}\triangle\mathbf{1} + \mathbf{Ax}(\sqrt{}) + \mathbf{Ax}(\text{Triv}) + \mathbf{Ax}(\parallel)$, p.705.

Ax(5nop) $\forall m, k (\forall \lambda \in {}^+F)[\lambda < v_m(k) \Rightarrow \exists k' (v_m(k') = \lambda)]$, p.706.

The intuitive idea of **Ax(5nop)** is that if a certain speed is realized by some observer then the *smaller speeds* are also realized by some observers.

Relnoph $\stackrel{\text{def}}{=} \mathbf{Relnoph}_0 + \mathbf{Ax}(5\text{nop})$, p.707.

Ax(group⁺) $(\forall m, k, m', k' \in \text{Obs})(\exists k'' \in \text{Obs})f_{mk} \circ f_{m'k'} = f_{mk''}$, p.410.

Ax(syt)* $f_{mk}(\bar{0}) = \bar{0} \Rightarrow f_{mk}(1_t)_t = f_{km}(1_t)_t$, p.721.

Ax(syx)* $(m, k \text{ are in pre-standard configuration})^{1305} \Rightarrow |f_{mk}(1_x)_x| = |f_{km}(1_x)_x|$, p.725.

(*1)–(*3) below are also potential axioms¹³⁰⁶ (or principles) connected with **Relnoph**.

(*1) The sum of finitely many small positive velocities is not infinite, formally: Let $j \in \omega$. Let $m_0, \dots, m_j \in \text{Obs}$. Assume m_i, m_{i+1} are in strict standard configuration¹³⁰⁷ and $v_{m_i}(m_{i+1}) < 1$, for all $i < j$. Then $v_{m_0}(m_j) \neq \infty$, p.710.

(*2) The sum of finitely many small positive velocities is nonnegative, formally: Let $j \in \omega$. Let $m_0, \dots, m_j \in \text{Obs}$. Assume m_i, m_{i+1} are in strict standard configuration and $v_{m_i}(m_{i+1}) < 1$, for all $i < j$. Then m_0 sees m_j moving forwards in direction 1_x , p.710.

¹³⁰⁴ **Ax1, Ax2, Ax3, Ax4.**

¹³⁰⁵ Cf. footnote 1300 on p.1260 for the notion of a pre-standard configuration.

¹³⁰⁶ (*1)–(*3) are schemas of formulas.

¹³⁰⁷ Assume $m, k \in \text{Obs}$. Then m and k are defined to be in *strict standard configuration* if they are in standard configuration, m sees k moving forwards in direction 1_x , k sees m moving backwards in direction 1_x , further $[v_m(k) = 0 \Rightarrow f_{km}(1_t)_t \cdot f_{km}(1_x)_x > 0]$ and $[v_m(k) = \infty \Rightarrow (f_{km}(1_t)_x > 0 \ \& \ f_{km}(1_x)_t < 0)]$. Cf. Def.5.0.42 (p.709) and Remark 5.0.43 (p.709).

(*3) The sum of finitely many small positive velocities is nonzero, formally: Let $0 < j \in \omega$. Let $m_0, \dots, m_j \in Obs$. Assume m_i, m_{i+1} are in strict standard configuration and $0 < v_{m_i}(m_{i+1}) < 1$, for all $i < j$. Then $v_{m_0}(m_j) \neq 0$, p.710.

“**Flxspecrel**”, the notation $\mathfrak{M} \models$ “**Flxspecrel**” was introduced on p.708.

Ax(natu) (*1) \vee (*2) \vee (*3),¹³⁰⁸ p.752

Ax(natu)⁺ $(\forall m, k, k' \in Obs) \sqrt{v_m(k')} \leq \sqrt{v_m(k)} + \sqrt{v_k(k')}$, p.753.

Ax(\exists body) $\forall m, k (\forall \ell \in Eucl)[(v_m(k) > 0 \wedge f_{mk}[\ell] = \ell) \Rightarrow (\exists b \in B) tr_m(b) = \ell]$, p.757.

Ax(5nop)⁻ $\forall m (\exists c \in {}^+F)(\forall \lambda \in {}^+F)[\lambda < c \Rightarrow (\exists k) v_m(k) = \lambda]$, p.761.

Relnoph⁻ is obtained from **Relnoph** by replacing **Ax(5nop)** with **Ax(5nop)**⁻, p.761.

Bax_{nobs}⁻ $\stackrel{\text{def}}{=} \mathbf{Bax}^- \setminus \{\mathbf{Ax5Obs}\} + \mathbf{Ax}(5\text{nop})^-$, p.762.

Relnoph⁻⁻ $\stackrel{\text{def}}{=} \mathbf{Relnoph}^- \setminus \{\mathbf{Ax}\Delta 1\} + \mathbf{Ax}(\text{symm})$, p.764.

egyezetetni
§4.3-ben
definícióval

levő

(12) The cone-smooth versions of our theories

Assume **Ax1**, **Ax2**, **Ax3₀**, **AxP1**. Let $m \in Obs$. Then

$$c_m : {}^nF \times \text{directions} \xrightarrow{\circ} F \cup \{\infty\}$$

is a partial function such that $c_m(p, d)$ is defined iff m sees a photon at point p moving forwards in direction d , and $c_m(p, d)$ is the speed of this photon,¹³⁰⁹ cf. pp. 473, 535. Further, for any $m \in Obs$ and $d \in \text{directions}$

$$c_m(d) \stackrel{\text{def}}{=} c_m(\bar{0}, d),$$

¹³⁰⁸**Ax(natu)** is a schema of formulas.

¹³⁰⁹There is only one such speed because of **AxP1**.

cf. p.488. Hence, $c_m : \text{directions} \xrightarrow{\circ} F \cup \{\infty\}$ is a partial function. (**Ax(consm)** below will imply that it is not partial. The notion of strongly continuous functions, partial derivatives etc. used in **Ax(consm)** below are formulated in our frame language on pp. 536, 518.) Now,

Ax(consm) $\stackrel{\text{def}}{=} \mathbf{Ax}(\mathbf{cnsm}_0) + \mathbf{Ax}(\mathbf{cnsm}_1) + \mathbf{Ax}(\mathbf{cnsm}_2)$ (cf. p.518), where

Ax(cnsm₀) c_m is a strongly continuous function defined on directions, p.519.

Ax(cnsm₁) For all $0 < i < n$, the partial derivative $(\partial_i c_m) : \text{directions} \rightarrow F$ is everywhere defined on the domain directions, p.519.

Ax(cnsm₂) For all $0 < i < n$, $\partial_i c_m$ is strongly continuous on the domain directions, p.519.

Let Th be one of our theories such that $Th \models \{ \mathbf{Ax1}, \mathbf{Ax2}, \mathbf{Ax3}_0, \mathbf{AxP1} \}$. Then

$\boxed{Th_\partial} \stackrel{\text{def}}{=} Th + \mathbf{Ax}(\mathbf{consm})$ is called the cone-smooth version of the theory Th , cf. p.521.

(13) Axioms and axiom systems not listed in this list

Ax_{OF}, p.30.

Ax_G, p.31. (**Ax_{OF}** and **Ax_G** are assumed throughout the present work.)

Ax1', p.45.

AxE₁, p.223.

AxE₂, p.223.

Ax2₁, p.223.

Ax5₁, p.223.

$\boxed{\text{Relphax}}$, p.223.

Ax□1', p.354.

Ax△2*, p.359.

Ax△3, p.406.

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Ax(isotropy'), p.400.

Ax(isotropy⁻), p.401.

Ax(homogeneity), p.405.

Ax(group⁻), p.410.

Ax(group), p.410.

$\boxed{\text{Flxspecrel}^+}$, p.425.

homogeneity

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 $\mathbf{R}(\mathbf{AxE})^-$, p.557.
 $\mathbf{R}(\mathbf{AxE}_{02})^-$, p.559.
 $\mathbf{R}(\mathbf{AxE}_{00})^-$, p.559.
 $\boxed{\mathbf{Reich}_0(Th)^-}$, p.563.
 $\mathbf{R}_k(\mathbf{AxE})$, p.574.
 $\boxed{\mathbf{Reich}'(Th)}$, p.580.
 \mathbf{AxR}^- , p.584.
 $\mathbf{AxR}^{1/2}$, p.584.
 \mathbf{AxR}^+ , p.584.
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Ax(sy₀), p.629.
Ax(5nop)⁻⁺, p.763.
Ax(cont), p.766.
Ax(cont)⁺, p.767.
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G₁, p.1172.
G₂, p.1172.
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G₄, p.1172.
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busg, p.1172.

Credits

Figures 258, 261, 333 are created from works by M. C. Escher, which appeared in D. R. Hofstadter: “Gödel, Escher, Bach”, Hungarian translation, Typotex Kiadó, 1998. Figure 355 (representing Gödel’s rotating universe) and Figure 290 are created from figures in S. W. Hawking and G. F. R. Ellis [126]. Figure 281 (view from near a black hole) is created from a figure in K. S. Thorne [258].

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