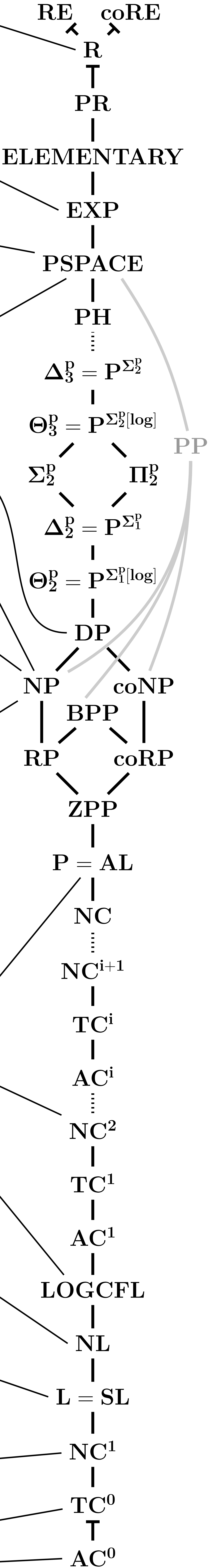


TM-Halt	in RE
SAT-FO-String	in R
Input: A first-order formula φ for strings Decision: Is φ satisfiable?	
2-PlayerCorridorTiling	EXP-C
Input: Tilings T and integer k (unary) Decision: Does player one has a winning strategy in the tiling game?	
QBF	PSPACE-C
Input: Quantified Boolean formula φ (in prenex normal form and CNF) Decision: Is φ satisfiable?	
CorridorTiling	PSPACE-C
Input: Tilings T and integer k (unary) Decision: Is there a $k \times l$ tiling for T ?	
SAT-UNSAT	DP-C
Input: Boolean formulas φ_1, φ_2 in CNF Decision: Is φ_1 satisfiable and φ_2 unsatisfiable?	
SAT	NP-C
Input: Boolean formula φ in CNF Decision: Is φ satisfiable?	
Tiling	NP-C
Input: Tilings T und integers c, r (unary) Decision: Is there a $c \times r$ tiling for T ?	
TSP	NP-C
Input: Weighted Graph G and $k \in \mathbb{N}$ Decision: Is there a circle in G with a weight smaller or equal to k that visits all nodes?	
For $f(n) \geq \log(n)$ <div> $\text{TIME}(2^{O(f)})$ $\text{SPACE}(f^2)$ </div> <div> $\text{NSPACE}(f) = \text{coNSPACE}(f)$ </div> <div> $\text{SPACE}(f)$ $\text{coNTIME}(f)$ $\text{NTIME}(f)$ $\text{TIME}(f)$ </div>	
HornSAT	P-C
Input: Finite set of Horn-clauses K Decision: Is K satisfiable?	
Determinant	in NC^2
AcyclicCS	LOGCFL-C
Input: Variables V , domain U , constraints C , such that (V, C) is acyclic Decision: Is there a solution $\sigma \subseteq V \times U$ such that $\sigma(C)$ is true?	
REACH	NL-C
Input: Graph $G = (V, E)$ and $s, t \in V$ Decision: Is there a path from s to t in G ?	
UREACH	L-C
Input: Undirected graph $G=(V, E)$ and $s, t \in V$ Decision: Is there a path from s to t in G ?	
FormulaValueProblem	NC^1 -C
Input: Variable free Boolean formula B Decision: Does B evaluate to true?	
Multiplikation	TC^0 -C
Addition	in AC^0

Arithmetical Hierarchy



Complexity Theory

Poster by Dr. Kai Sauerwald (Artificial Intelligence Group, FernUniversität in Hagen); based on a lecture by Prof. Dr. Schwentick (LogiDAC, TU Dortmund University).

Parameterized Problems	
A tuple (Q, κ) is a parameterized problem, if $Q \subseteq \Sigma^*$ and $\kappa : \Sigma^* \rightarrow \mathbb{N}$ is computable in polynomial time.	
Descriptive Complexity & Parametrization	<div> Complexity & Logic </div> <div> $\text{PSPACE} \dots \text{PFP}$ $\text{NP} \dots \text{ESO}$ $\text{P} \dots \text{HornESO, LFP}$ $\text{NL} \dots \text{TC}$ $\text{L} \dots \text{DTC}$ $\text{TC}^0 \dots \text{FO}(+, \times) + \text{C}$ $\text{REG} \dots \text{MSO}$ $\text{AC}^0 \dots \text{FO}(+, \times)$ </div>
	<div> Proof systems </div> <div> $\text{PSPACE} = \text{IP}$ NP_2 AM MA BPP $\text{NP} = \text{PCP}(\log, \text{poly}) = \text{PCP}(0, \text{poly}) = \text{PCP}(\log, 1)$ </div>
Complexity Classes and Logic	PCP (<i>probabilistically checkable proof</i>) $\text{PCP}(\mathcal{F}, \mathcal{G})$ is the class of languages L such there is a verifier V that <ul style="list-style-type: none"> uses $\leq r(n)$ random bits, $(r \in \mathcal{F})$ reads $\leq q(n)$ bits of the proof, $(q \in \mathcal{G})$ accepts for a proof π everything from L and does not accept any $x \notin L$ with probability $> \frac{1}{2}$.
Optimization	Class operators For every \mathcal{C} which is closed under Turing-reduction holds: $\text{BP} \cdot \text{BP} \cdot \mathcal{C} \subseteq \text{BP} \cdot \mathcal{C}$ $\oplus \cdot \oplus \cdot \mathcal{C} \subseteq \oplus \mathcal{C}$ $\oplus \cdot \text{BP} \cdot \mathcal{C} \subseteq \text{BP} \cdot \oplus \cdot \mathcal{C}$ $\exists \cdot \mathcal{C} \subseteq \text{BP} \cdot \oplus \cdot \mathcal{C}$ $\exists \cdot \text{BP} \cdot \mathcal{C} \subseteq \text{BP} \cdot \exists \cdot \mathcal{C}$ $\exists \cdot \text{BP} \cdot \text{P} = \text{MA}$ $\text{BP} \cdot \exists \cdot \text{P} = \text{AM}$
	Theorem Chandra, Kozen, Stockmeyer (a) Ist $S(n) = \Omega(\log n)$, so gilt $\text{ASPACE}(S) \subseteq \text{TIME}(2^{O(S)})$ (b) Ist $T(n) = \Omega(n)$, so gilt $\text{TIME}(T) \subseteq \text{ASPACE}(\log T)$
Immerman–Szelepcsényi theorem	
For space constructible S with $S(n) \geq \log n$ holds: $\text{NSPACE}(S) = \text{coNSPACE}(S)$	
Savitch's theorem Savitch	
For space constructible S with $S(n) \geq \log n$ holds: $\text{NSPACE}(S) \subseteq \text{SPACE}(S^2)$	
Space hierarchy theorem Stearns, Szevietowski	
For time constructible f, g with $f(n) \in \Omega(\log n)$ and $g(n) \in \omega(f(n))$ holds: $\text{SPACE}(f) \subsetneq \text{SPACE}(g)$ $\text{NSPACE}(f) \subsetneq \text{NSPACE}(g)$	
Time hierarchy theorem Hartmanis, Stearns	
For time constructible f, g with $f(n) \in \Omega(n)$ and $g(n) \in \omega(f(n) \cdot \log(f(n)))$ holds: $\text{TIME}(f) \subsetneq \text{TIME}(g)$	