## Scott Aaronson: Quantum Complexity and Quantum Optics

December-30-13 2:37 AM

See also <a href="http://quantumrio.wordpress.com/">http://quantumrio.wordpress.com/</a> , problem sets at
https://www.dropbox.com/sh/cazr7ep5n6f14ya/eCaZnKXX1B
1. ECT & complexity
2. Linear Optics & Boson Sampling.  3. Post selection KLM, Approximate Boson Sampling. (KLM: Knifl, Laffmme, Millown, http://arxiv.org/abs/quantph/00060
3. Post selection KLM, Approximate Boson
SAMIMAG. (KLM·KNIK, Lafflumne, Millsum) http://arxiv.org/abs/quantph/00060
4. Scalability & Verification of Boson sampling devices.
Twing Machine
The Physical Church-Thesis: Anything that can be physically computed can be computed by a Turing machine.
Beyond Turing:
1. "Zeno Computer" - fails as at 10^43 Hz the energy needed to cool the computer will turn it into a
black hole.  2. "Special Relativity Computer" - will need an exponential amount of energy to accelerate.
A definition of the class "P".
ECT: "Extended Church-Turing Thesis": P is always the same, and the physical P is the CS P.
A definition of "NP". $P = NPZ$ Conjective: $P \neq NP$ .
Det L is "NP hard" it NPCPL
p up oracle for L.
DOF Lis is "NP-complete" if it is NN-bod
& in NP.
PENPEPSPACEE EXP

	Conj: All inclusions are strict.
	Thn: PFEXP.
_	Lecture II
	A difference between factorization & all known NP-complete problem: In factorization here is
	uniqueness of solutions.
	Chim FuctoriantionE NP (CO-NP).
	Chim If $\exists L \in NP \cap (co-NP)$ s.t. L is NP complete, then $NP = Co-NP$ .
	But, conjecture NP+ coNP.
	The 'phynomial Hierarchy' (PH)  Oth level: P  St lovel: NP, CONP  2nd level: NPNP, CONPNP  3rd level: NP(NPNP)  This is non-degenerate.  This viol: NP(NPNP)  HC. http://en.wikipedia.org/wiki/Polynomial hierarchy  This Whole hierarchy is Contained in P-SPace.  The If graph isomorphism is NP-complete,  Then If graph isomorphism is NP-complete,
,	#P: count # of solns of P problems.
	Example The matching problem in a bi-partitle gaph is P, yet the corresponding counting policy is #P-complete.
	<u> </u>

Per(A) = Z T/ aioti)  for the V-V adjacery metrix of a bipetite graph, les counts metabings, so per is #P - complete.  NPE PH = p <sup>#P</sup> c PSPACE  Toda 1991 PH c p <sup>#P</sup> BPP: Bounded-error Prohibitistic Pdy time: The class of all Lefo, pf* st. 7 poly-time Twing medica st. mulmostry uniform * XEL = P P[M(x,r) accepts] > 2  * X & L = P P[M(x,r) accepts] > 2  The only needed property of x = 1 kp=2 is 0<< <p>PP: Some as BPP, but with x=p.  Chila p=BPP = PIC p<sup>#P</sup>C PSPACE  BPP CNP unknown. Than (sipstor) BPPC NPNP  NP CBPP whenam Than NICBPP = PH = NPNP</p>	Le permanent of a matrix A.
IS #P - complete.  NPE PHEP#C PSPACE  Toda 1991 PHC P#P  BPP: Bounded-error Probabilistic Polytime:  The choss of all LC 60, 13 st. I poly-time  Twing makine s.t. mountain unitorman  * XEL => P[M(X,r) accepts] > \frac{1}{3}  * X & L => P[M(X,r) accepts] < \frac{1}{3}  [The only needed property of <= \frac{1}{3} \lambda p=\frac{2}{3} is O << \p>    PP: Same as BPP, but with <= \frac{1}{3}  Chila p=BPP = PIC p#PC PSPACE  BPP CNP unknum.  Than (sipstor) BPPC NPNP 0	· · · · · · · · · · · · · · · · · · ·
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Twing machine s.t. moon string uniform a distribut; n, poly length  * XEL => Pr[M(X,r) accepts] > \frac{1}{3}  * X \in L => pr[M(X,r) accepts] < \frac{1}{3}  The only needed property of <=\frac{1}{3} kp=\frac{2}{3} is O<<<\p>(K)  PP: Same as BPP, but with <=\beta.  Chila pe BPP = PI < p \text{#PC PSPACE}  BPP CNP unknown.  Than (sipstar) BPPC NPNP o	BPP: Bounded-error Probabilistic Polytime:
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	BPPCNP unknown.
NPCBPP WKnown Thm NICBPP => PH = NPNP	
	NPCBPP WKnown Thm NICBPP => PH = NPNP

BOP The class of L < 20,13 \* s.t. 7 classical Roly-time twing machine M s.t. VXELO, 17\* Montputs a quantum circuit Cx s.t. XEL = ) Cx accepts w/ 1005 >2/3  $x \notin L = ) Cx$ 10) — Poly # 26 — 2ntput.
107 — 9 7tes dain PCBPPCBQPCPSPACECEXP The relationship between NP & BQP is unknown Conjecture P=BPPFBQP Follows from the existence of a good chough pseudo-random number generator