

홀로그래피 이중성 ☯ 과 고차스핀 중력 이론



정의헌

양자 역학

특수 상대성 이론

양자 장론
(입자물리학)

일반 상대성 이론
(아인슈타인 중력)

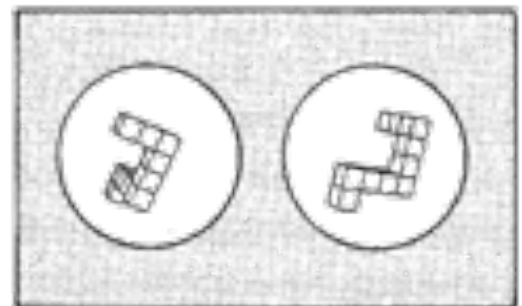
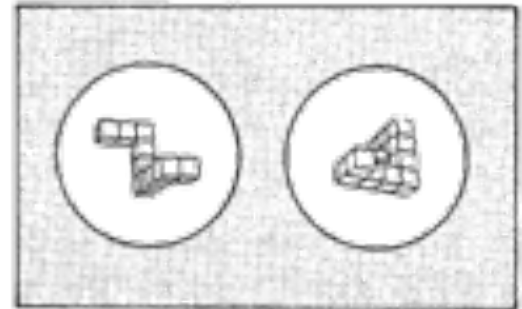
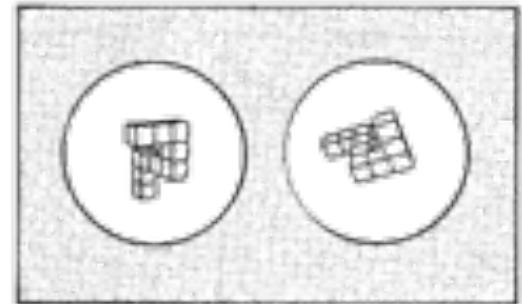
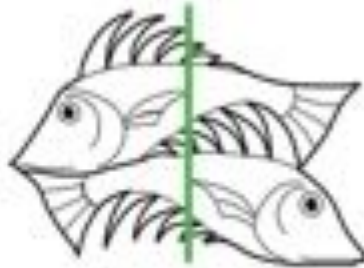
양자 중력 이론

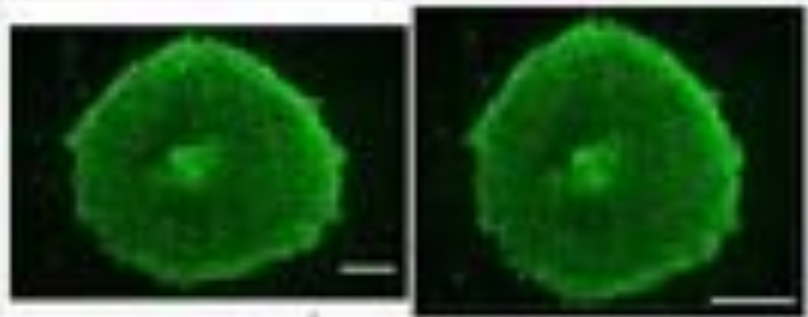
대칭성

대칭성 (Symmetry)

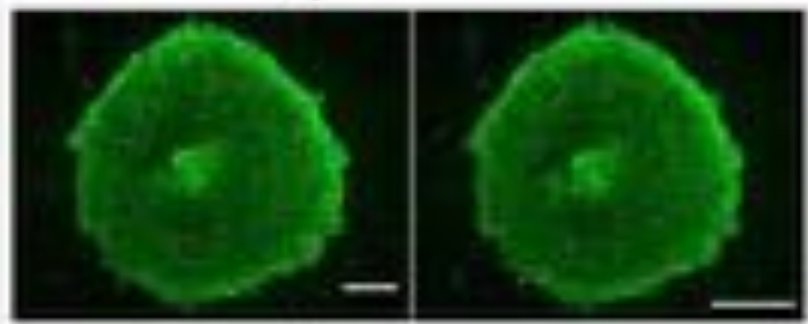


대칭성 (Symmetry)





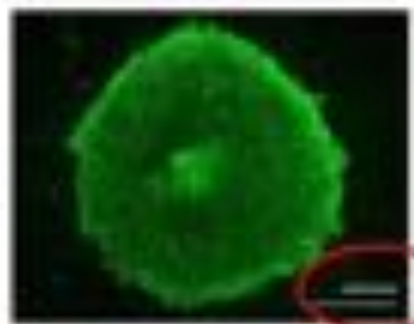
1. 서로 다른 두 빛에 반응하는 두개의 세포,
눈앞에 삼면 그대로의 이미지가입니다.



2. 좌측의 세포를 모두 선으로 채워주세요
조금씩입니다. 아라... 언젠가 끝이있어야겠지



3. 두 이미지를 잘 투명하게 조절하여 겹쳐줍니다.



투명하게 겹쳐지지
않는 부분이
이 표시 부분인데,
이것이 식이하는 데는?
→

4. 원래 하나였단 눈에 보여주세요, ———

5. 어떤 식으로 겹쳐지는 것이 3개에 더 걸렸요..

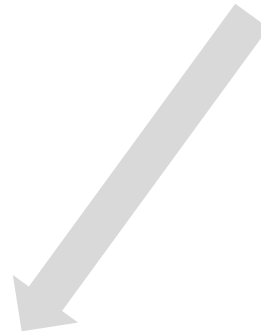
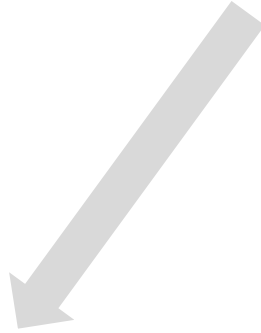
양자 역학

특수 상대성 이론

양자 장론
(입자물리학)

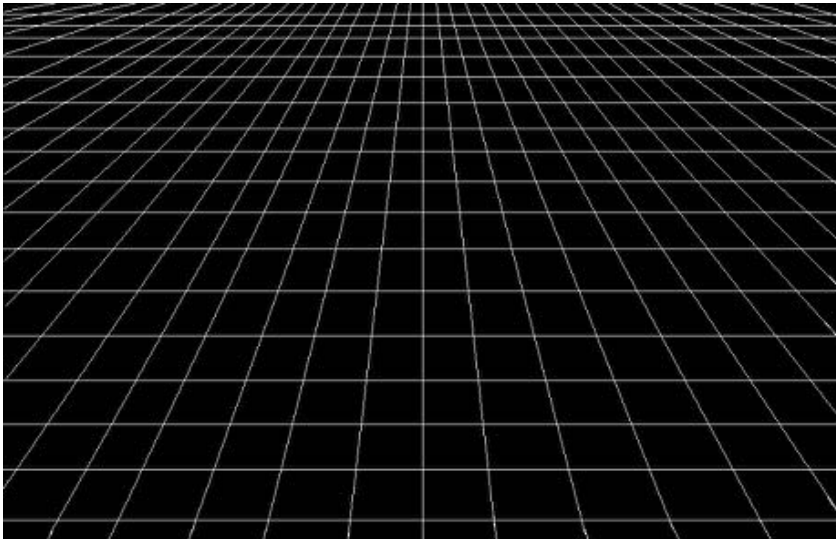
일반 상대성 이론
(아인슈타인 중력)

양자 중력 이론



특수 상대성 이론

(텅빈) 시공간의 대칭성



민코프스키 공간 (Minkowski Space)

- 평행이동
- 회전
- 로렌츠 변환



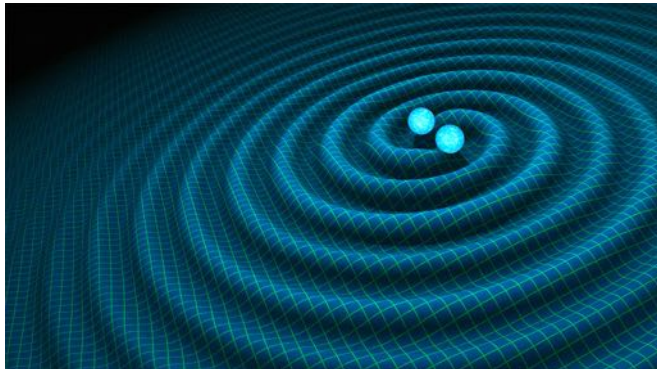
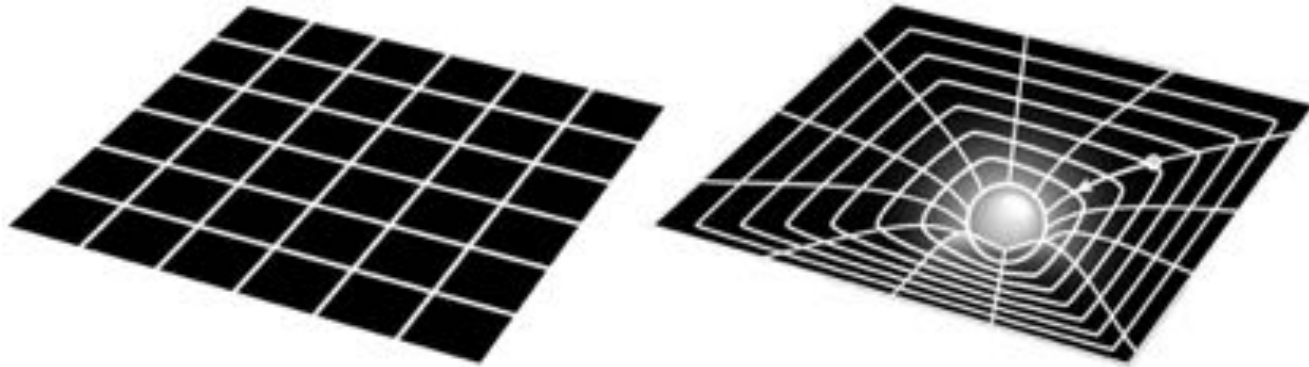
일반 상대성 이론

등가 원리 (Equivalence Principle)



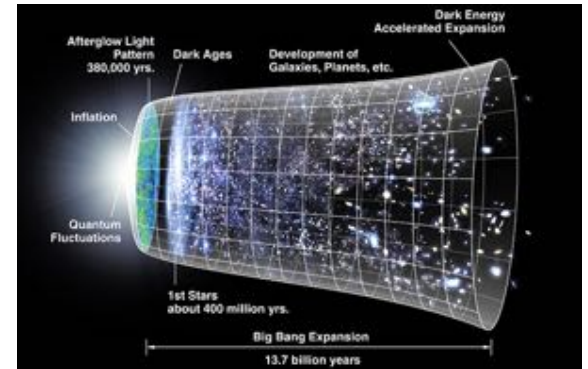
일반 상대성 이론

중력 : 휘어진 시공간



중력파

우주론



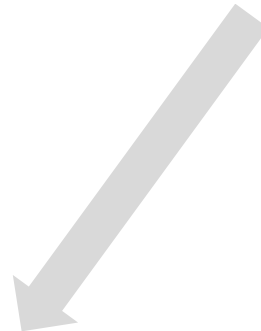
양자 역학

특수 상대성 이론

양자장 이론
(입자물리학)

일반 상대성 이론
(아인슈타인 중력)

양자 중력 이론

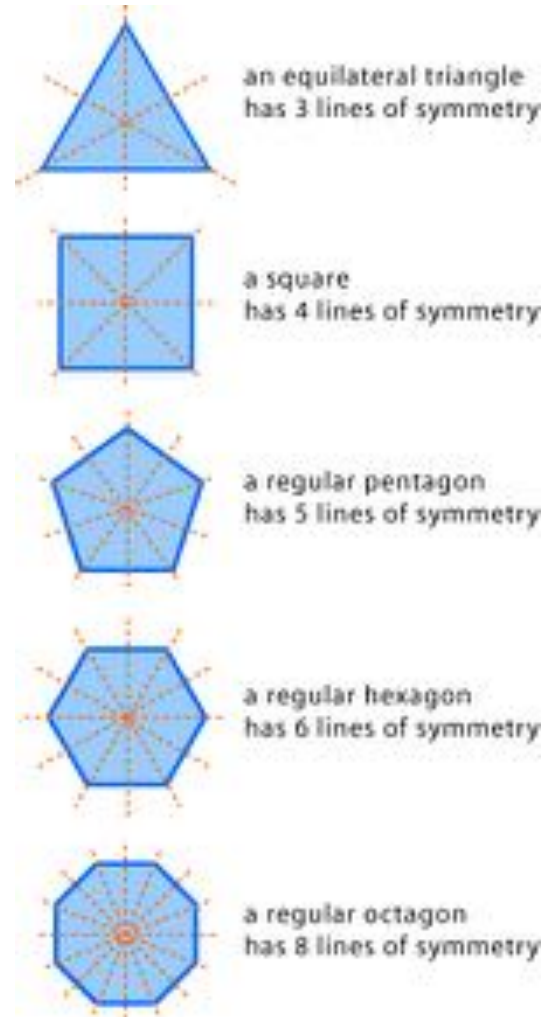


양자역학 + 특수 상대성 이론

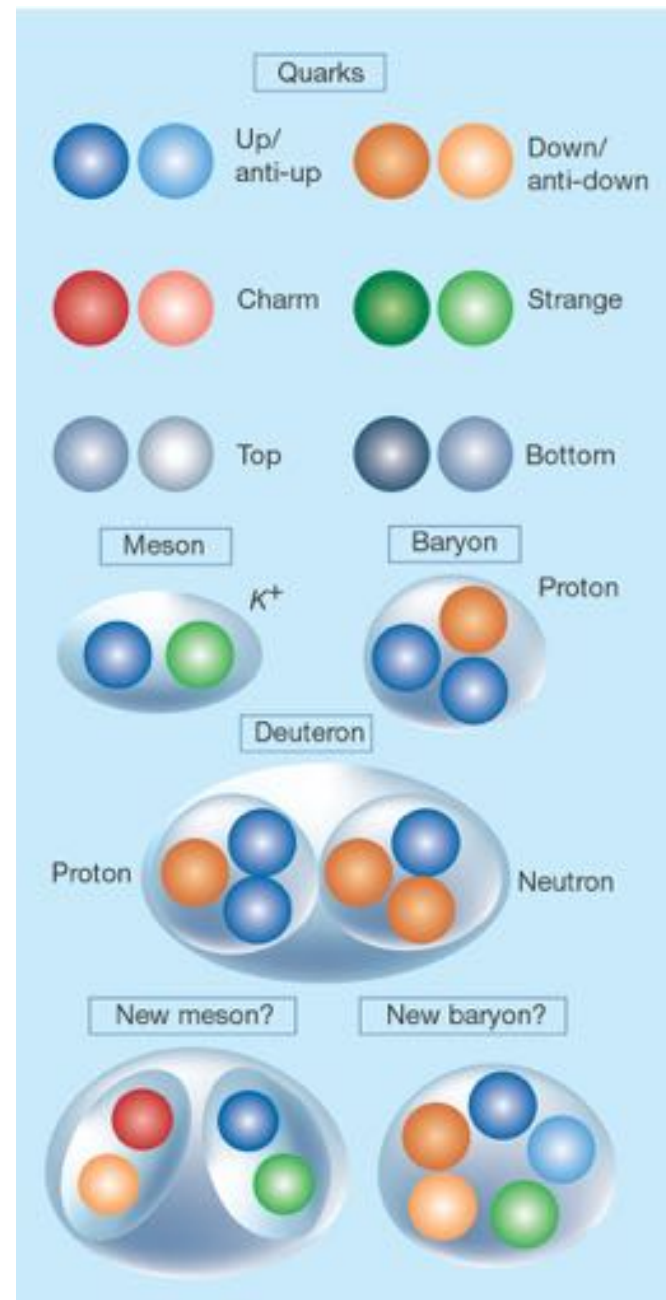
자연의 기본 입자

시공간+내적 대칭성으로 결정

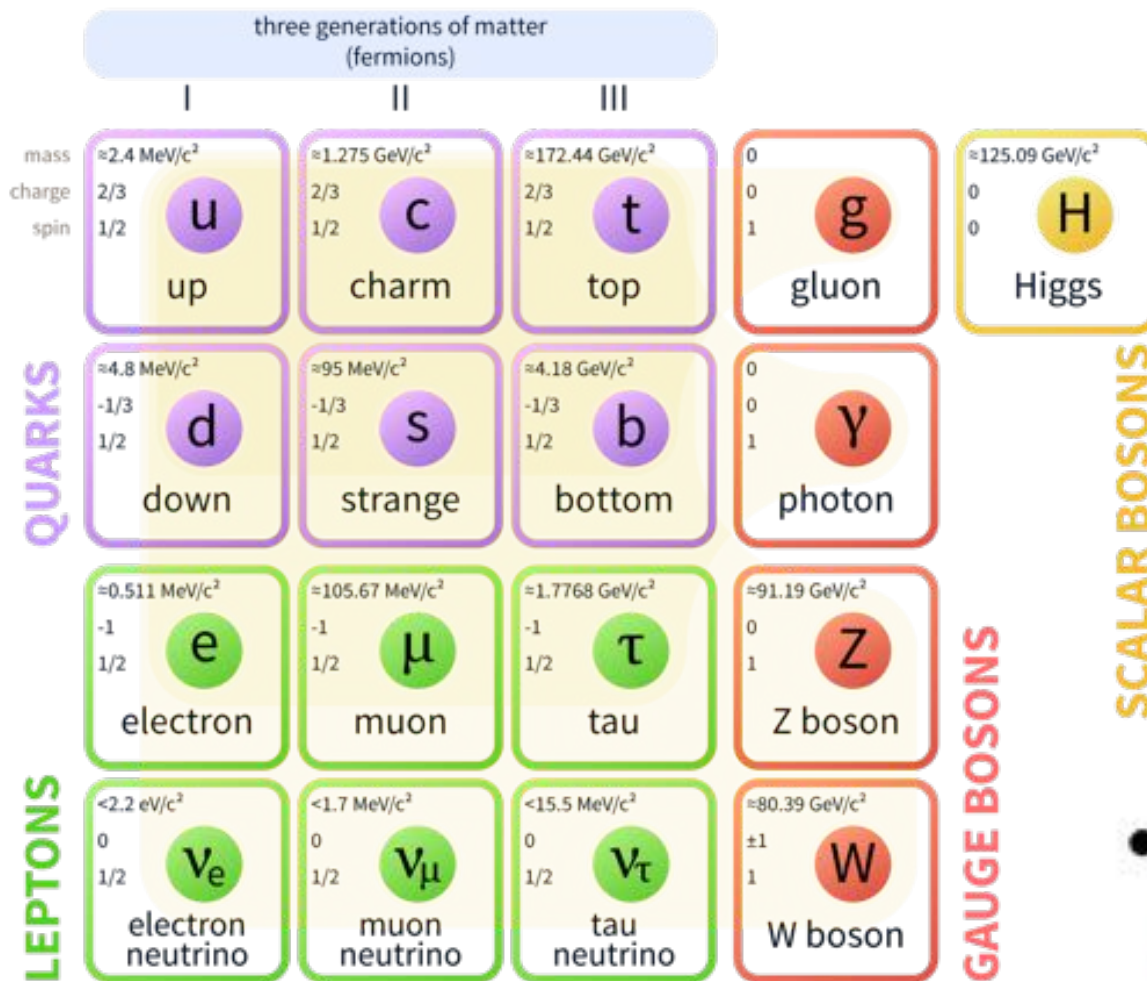
→ 질량, 스핀, 전하



Name	Mass (MeV/c ²)	Lifetime (s)	Spin J^P [h]	Charge Q/e	Isospin I	Strangeness S	
QUARKS:							
"up"	u	411?	$\infty?$	$\frac{2}{3}$	$\frac{1}{2}$	0	
"down"	d	411?	$\infty?$	$-\frac{1}{3}$	$\frac{1}{2}$	0	
"strange"	s	558?	$\infty?$	$-\frac{1}{3}$	0	-1	
MESONS:							
pion	π	139	$\pi^\pm: 2.6 \times 10^{-8}$ $\pi^0: 8.3 \times 10^{-17}$	0 ⁻	-1, 0, +1	1	0
kaon	K	495	$K^\pm: 1.2 \times 10^{-8}$ K^0 : ambiguous	0 ⁻	-1, 0, +1	$\frac{1}{2}$	$K^0, K^+ : +1$ $\bar{K}^0, K^- : -1$
eta	η	549	8.9×10^{-15}	0 ⁻	0	0	0
rho	ρ	770	4.3×10^{-24}	1 ⁻	-1, 0, +1	1	0
omega	ω	783	6.58×10^{-23}	1 ⁻	0	0	0
phi	ϕ	1020	1.6×10^{-22}	0 ⁻	0	0	0
	K^*	892	1.33×10^{-23}	1 ⁻	-1, 0, +1	$\frac{1}{2}$	$K^{*0}, K^{*+} : +1$ $\bar{K}^{*0}, K^{*-} : -1$
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
BARYONS:							
nucleon	N	938	proton (p) : ∞ neutron (n) : 920	$\frac{1}{2}^+$	0, +1	$\frac{1}{2}$	0
lambda	Λ	1116	2.6×10^{-10}	$\frac{1}{2}^+$	0	0	-1
sigma	Σ	1190	$\Sigma^\pm : \approx 10^{-10}$ $\Sigma^0 : < 10^{-14}$	$\frac{1}{2}^+$	-1, 0, +1	1	-1
cascade	Ξ	1320	$\approx 2 \times 10^{-10}$	$\frac{1}{2}^+$	-1, 0	$\frac{1}{2}$	-2
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
delta	Δ	1232	5×10^{-24}	$\frac{3}{2}^+$	-1, 0, +1, +2	$\frac{3}{2}$	0
	Σ^*	1383	1.6×10^{-23}	$\frac{3}{2}^+$	-1, 0, +1	1	-1
	Ξ^*	1530	6.6×10^{-23}	$\frac{3}{2}^+$	-1, 0	$\frac{1}{2}$	-2
Omega	Ω	1672	1.3×10^{-10}	$\frac{3}{2}^+$	-1	0	-3
	⋮	⋮	⋮	⋮	⋮	⋮	⋮



Standard Model of Elementary Particles



SCALAR BOSONS

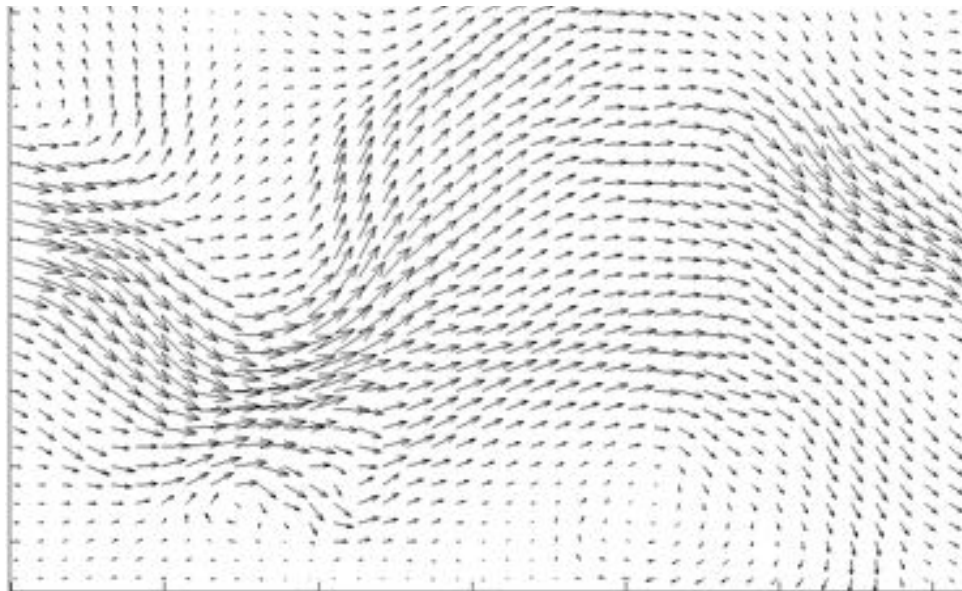
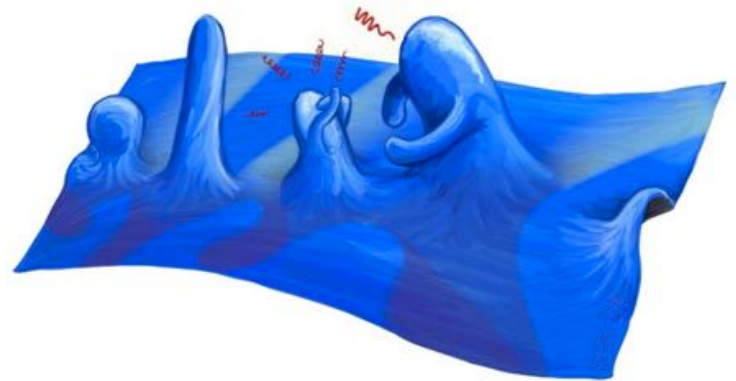
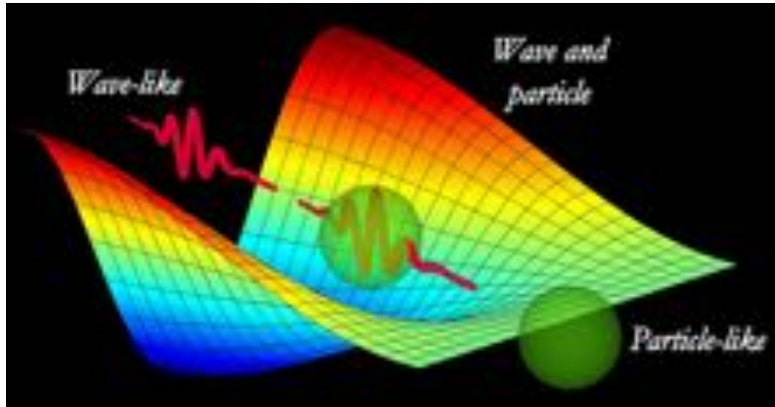
GAUGE BOSONS



Weak (Electroweak)	Electromagnetic	Strong
$W^+ W^- Z^0$	Photon	Gluon
Quarks and Leptons	Quarks and Charged Leptons and $W^+ W^-$	Quarks and Gluons



입자 ☯ 파동 이중성



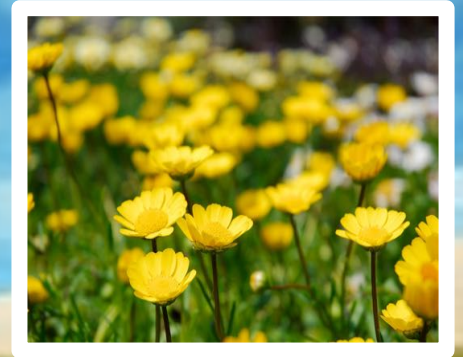
장론 (Field Theory)



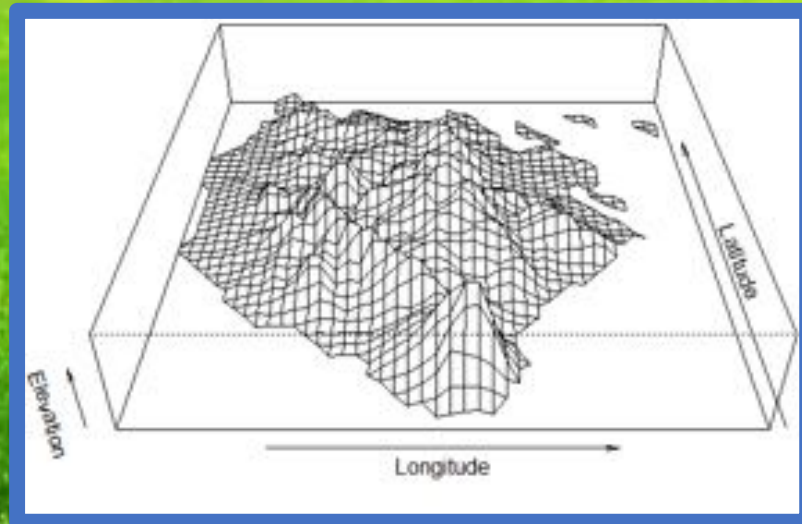
Photon



W boson



Electron



Graviton

Standard Model of Elementary Particles

three generations of matter
(fermions)

	I	II	III		
mass	$\approx 2.4 \text{ MeV}/c^2$	$\approx 1.275 \text{ GeV}/c^2$	$\approx 172.44 \text{ GeV}/c^2$	0	$\approx 125.09 \text{ GeV}/c^2$
charge	2/3	2/3	2/3	0	0
spin	1/2	1/2	1/2	1	0
	u up	c charm	t top	g gluon	H Higgs
QUARKS	$\approx 4.8 \text{ MeV}/c^2$	$\approx 95 \text{ MeV}/c^2$	$\approx 4.18 \text{ GeV}/c^2$	0	
	-1/3	-1/3	-1/3	0	
	1/2	1/2	1/2	1	
	d down	s strange	b bottom	γ photon	
LEPTONS	$\approx 0.511 \text{ MeV}/c^2$	$\approx 105.67 \text{ MeV}/c^2$	$\approx 1.7768 \text{ GeV}/c^2$	$\approx 91.19 \text{ GeV}/c^2$	
	-1	-1	-1	0	
	1/2	1/2	1/2	1	
	e electron	μ muon	τ tau	Z Z boson	
	$< 2.2 \text{ eV}/c^2$	$< 1.7 \text{ MeV}/c^2$	$< 15.5 \text{ MeV}/c^2$	$\approx 80.39 \text{ GeV}/c^2$	
	0	0	0	± 1	
	1/2	1/2	1/2	1	
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson	

0	G
0	
0	
2	

Graviton

TENSOR (SPIN 2) BOSON

GAUGE BOSONS

SCALAR BOSONS



	Gravity	Weak (Electroweak)	Electromagnetic	Strong
Carried By	Graviton <small>(not yet observed)</small>	$W^+ W^- Z^0$	Photon	Gluon
Acts on	All	Quarks and Leptons	Quarks and Charged Leptons and $W^+ W^-$	Quarks and Gluons

양자 역학

특수 상대성 이론

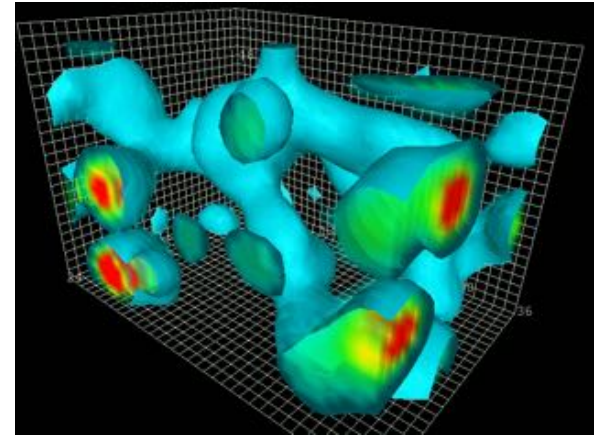
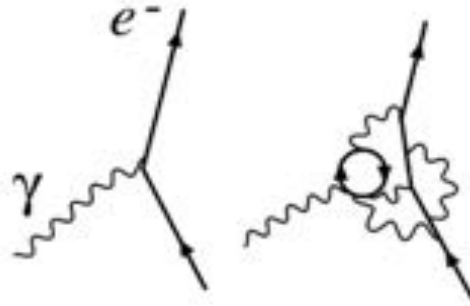
양자 장론
(입자물리학)

일반 상대성 이론
(아인슈타인 중력)

양자 중력 이론

양자적 동요

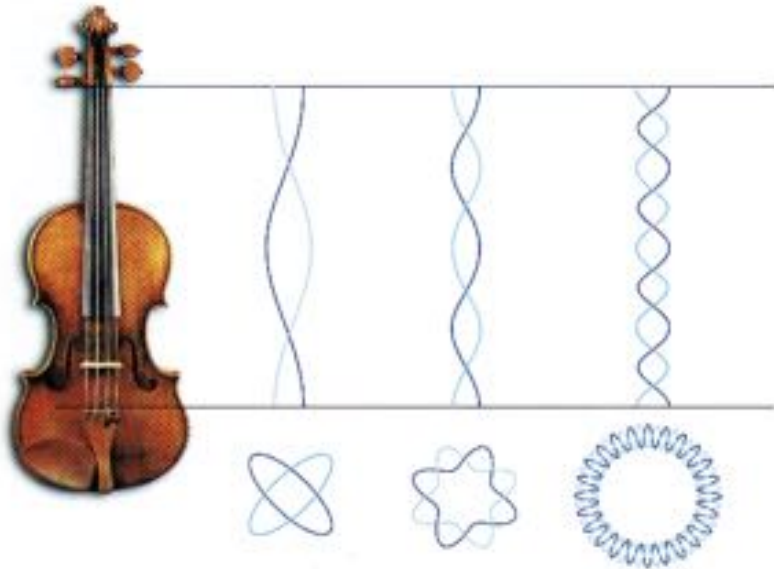
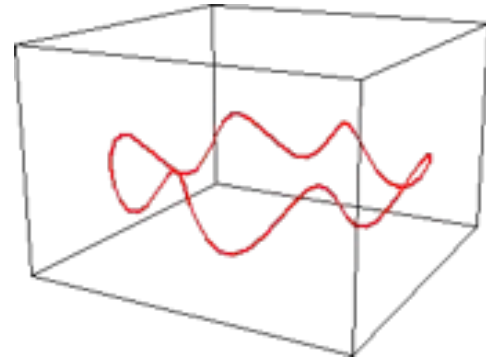
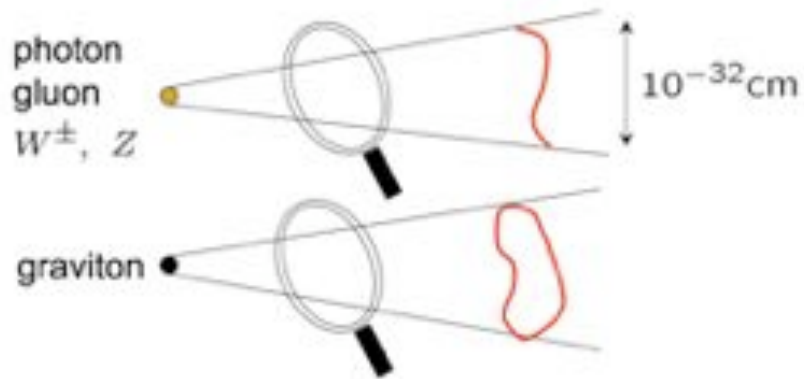
- 무한대의 물리량
- 재규격화



중력자(만) 양자화

- 재규격화 불가능
- 정합적이지 못함

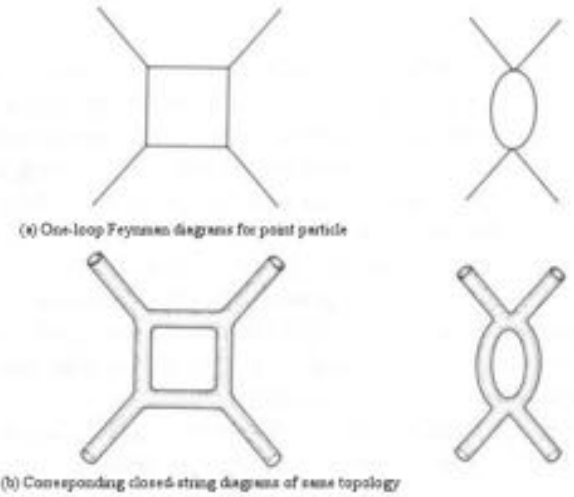
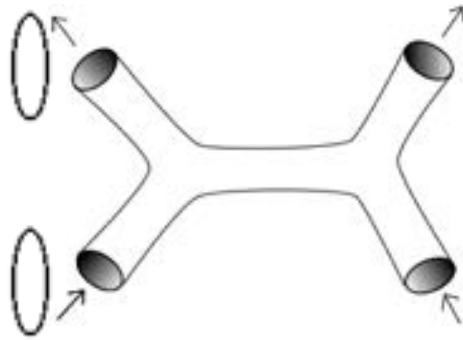
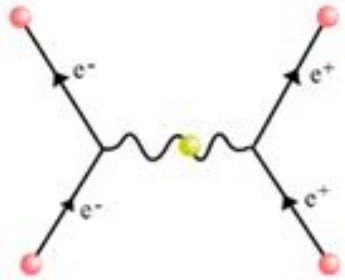
끈 이론



무한히 많은 입자

➤ 무한히 높은 질량

➤ 무한히 높은 스핀



끈 이론

- 모든 물리량 유한
- 재규격화 불필요

: 중력자를 포함해 무수히 많은 입자들을 기술하는 정합적 양자이론!



양자 중력

- 물리량 계산 : 이론적으로는 OK (끈 이론)
- 개념적 이해 :

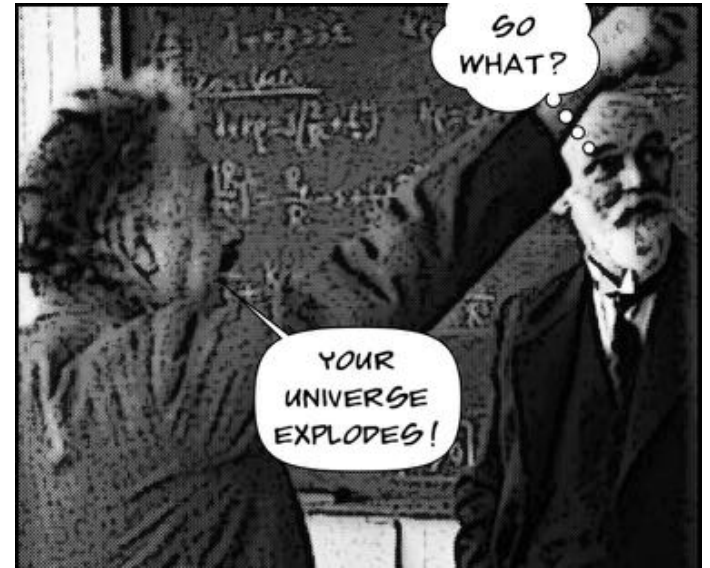
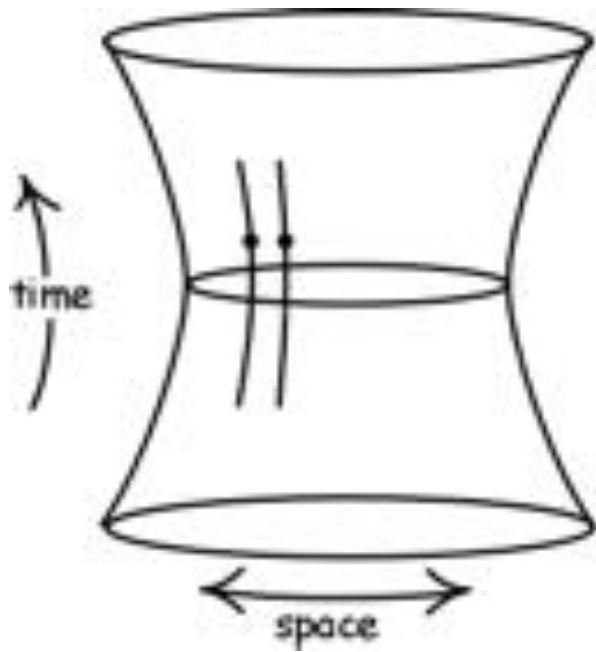




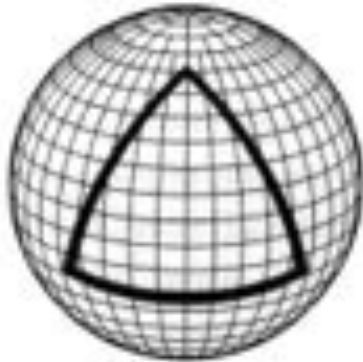
홀로그래피 이중성



또 다른 대칭적 시공간, 드지터 공간 (De Sitter Space)

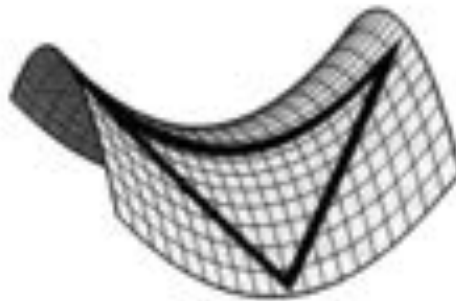


드지터



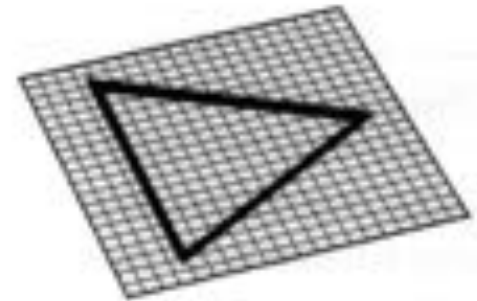
Positive Curvature

???



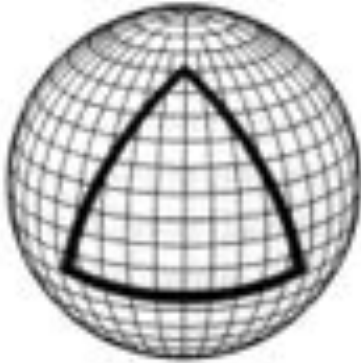
Negative Curvature

민코프스키



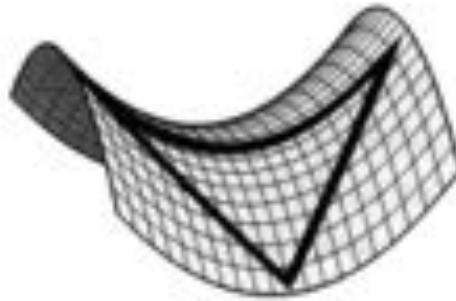
Flat Curvature

드지터



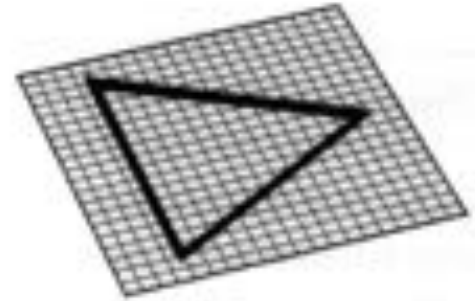
Positive Curvature

안티드지터



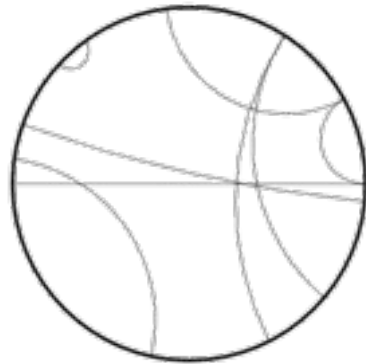
Negative Curvature

민코프스키



Flat Curvature

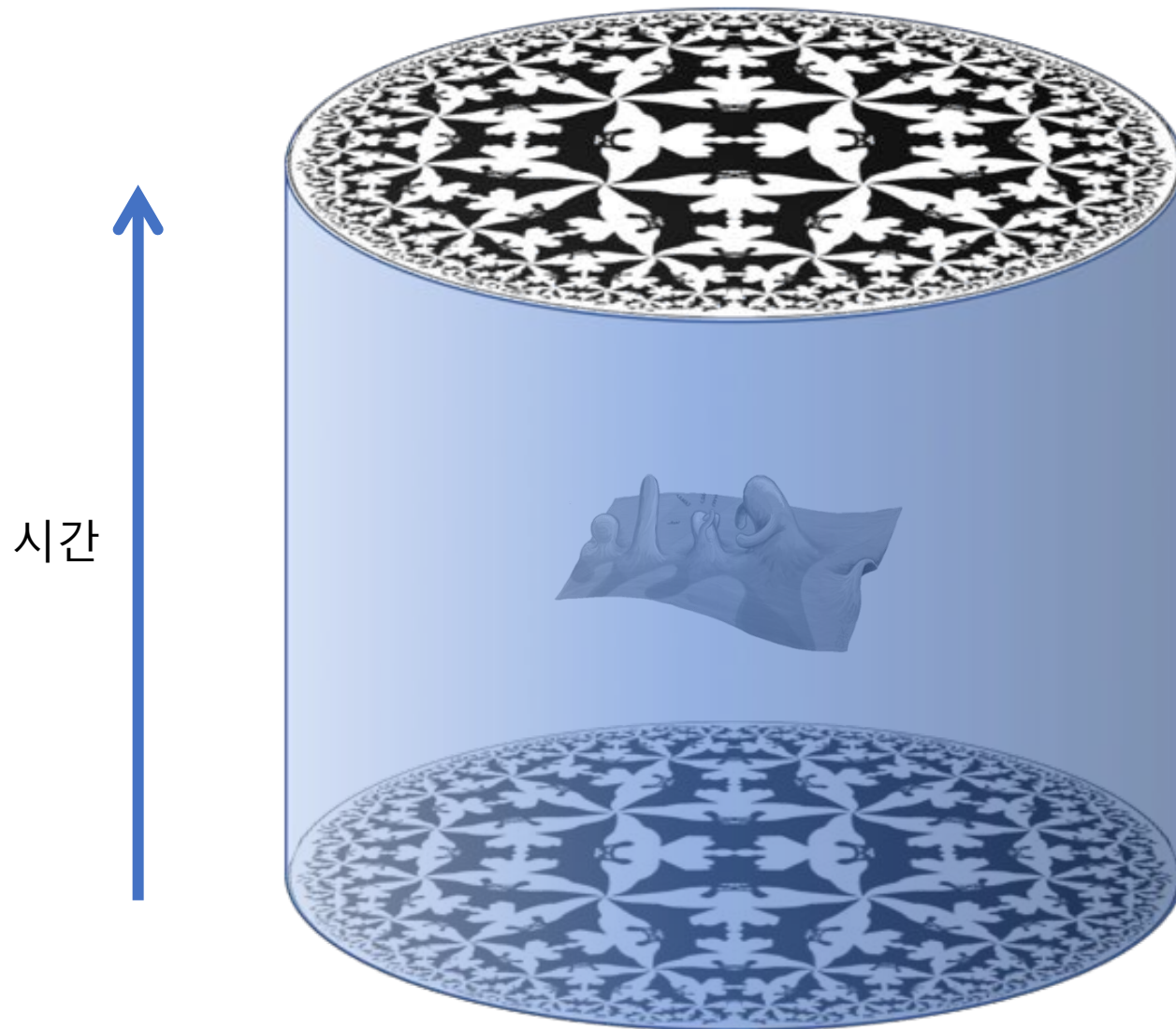
쌍곡 공간 (Hyperbolic Space)



천사와 악마 - 에셔 1960



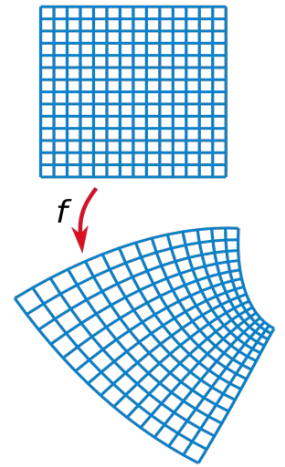
안티드지터 공간 (Anti De Sitter Space)



4차원 안티드지터 공간의 **대칭성**



3차원 시공간의 **등각대칭성**



등각대칭성

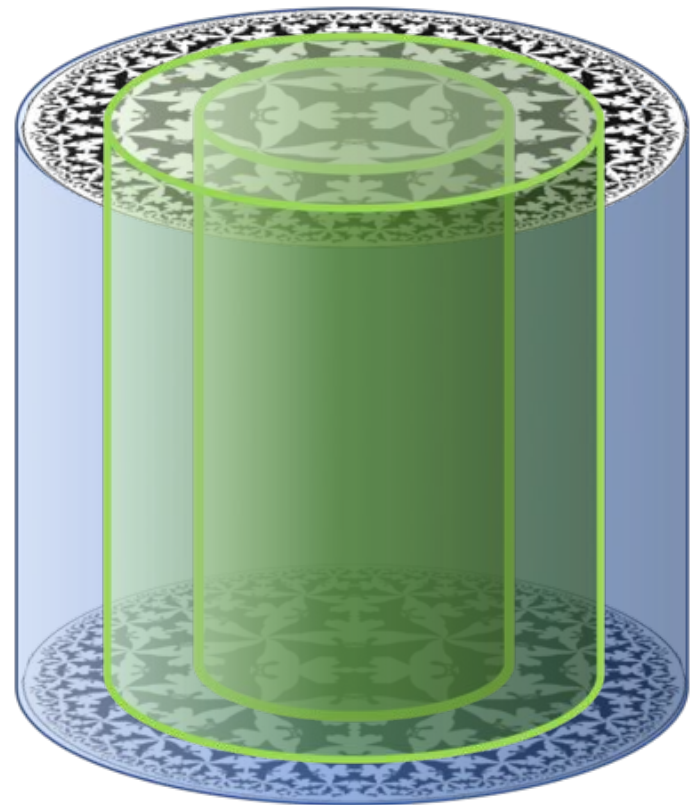
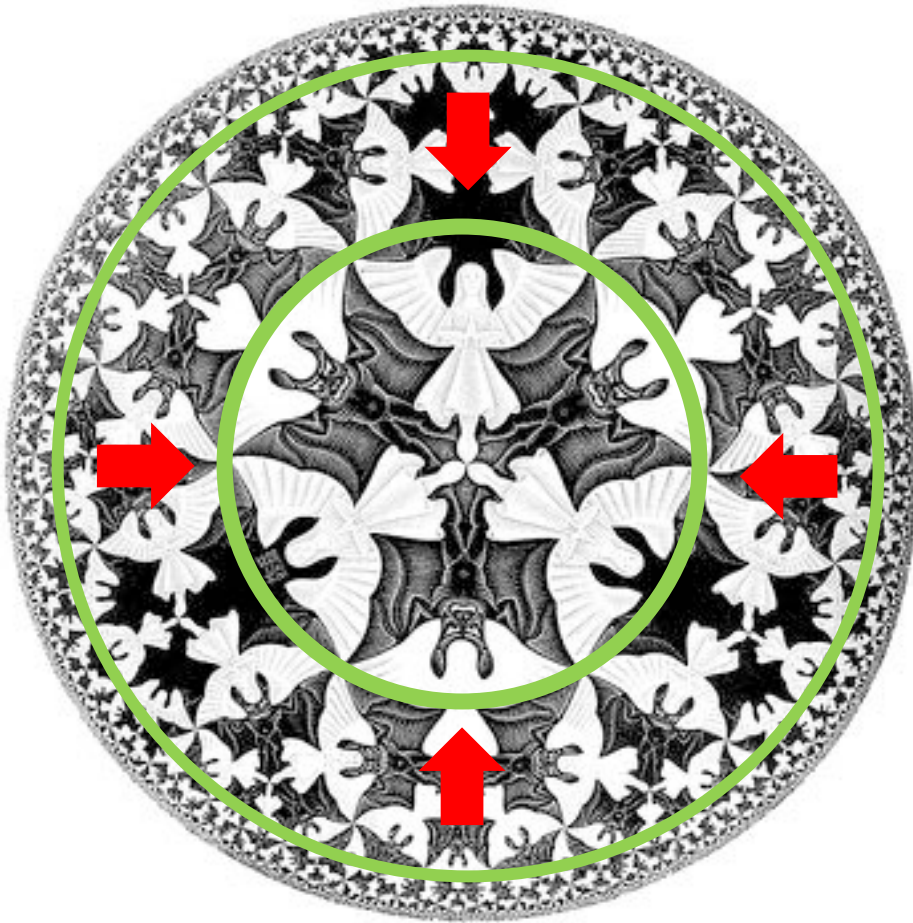
- 평행이동
- 회전
- 로렌츠 변환
- **늘임**
- 특수 등각 변환



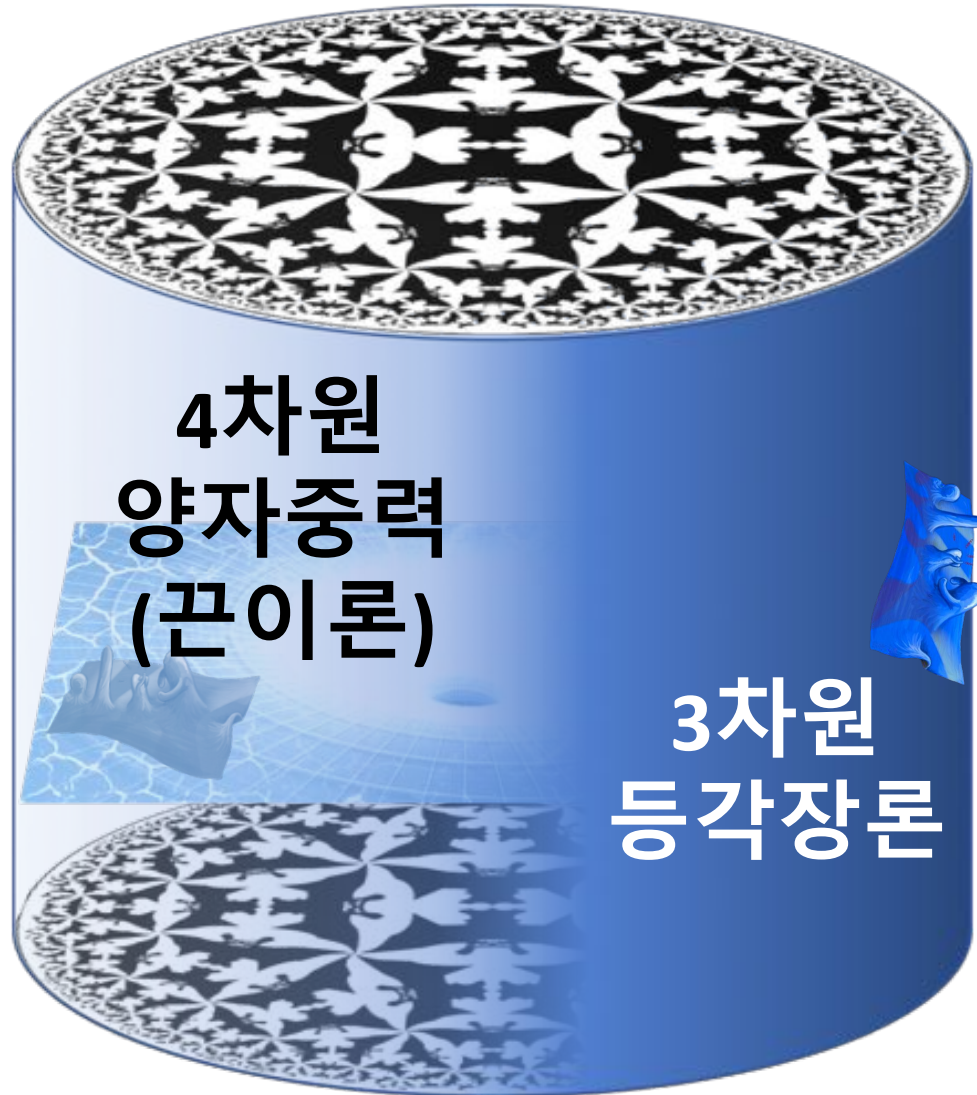
4차원 안티드지터 공간의 **대칭성**



3차원 시공간의 **등각대칭성**

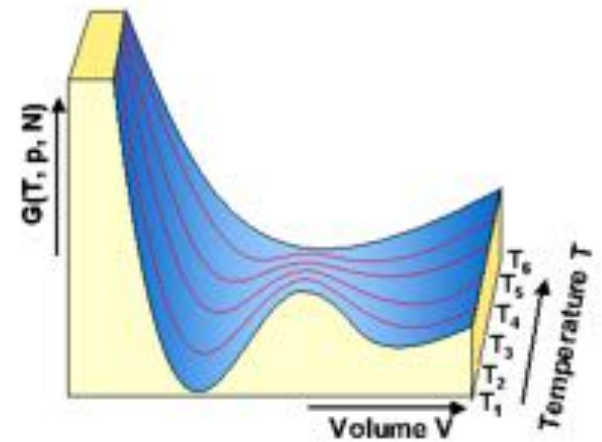
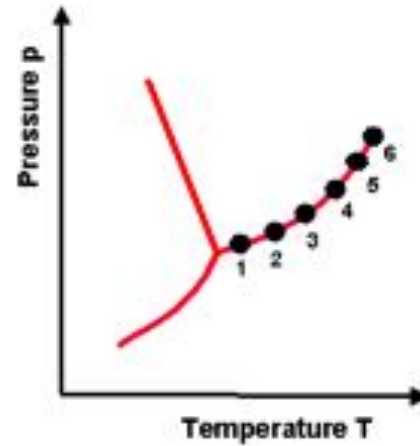
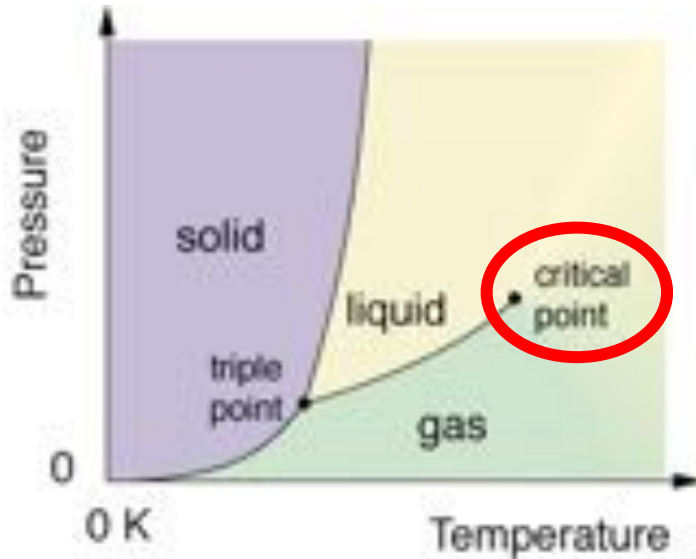


두개의 이론

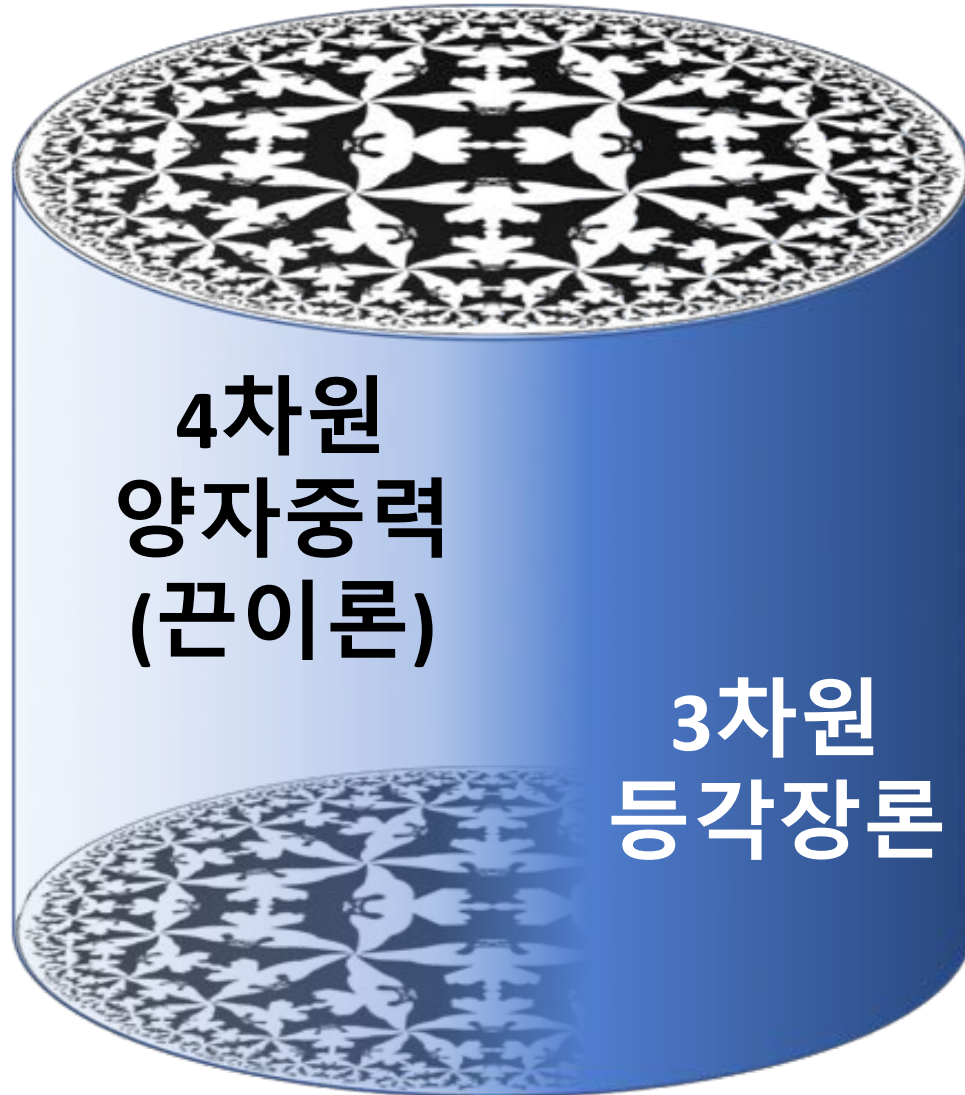


등각 장론 (Conformal Field Theory)

2차 상전이 현상 (2nd order phase transition)



두개의 이론



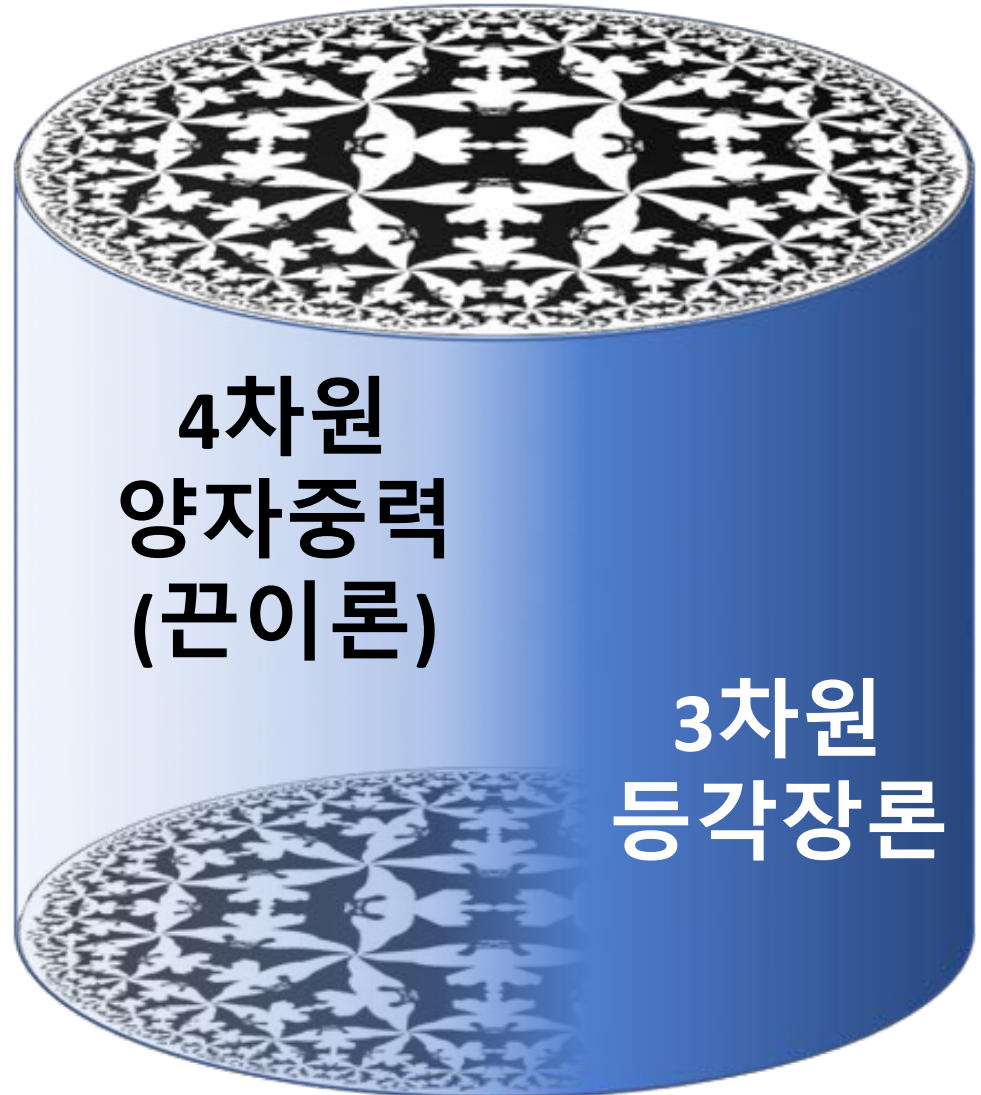
두개의 이론

홀로그래피 이중성



홀로그래피 이중성

모든 물리량 사이에
일대일 대응성 존재



4차원
양자중력
(끈이론)

3차원
등각장론

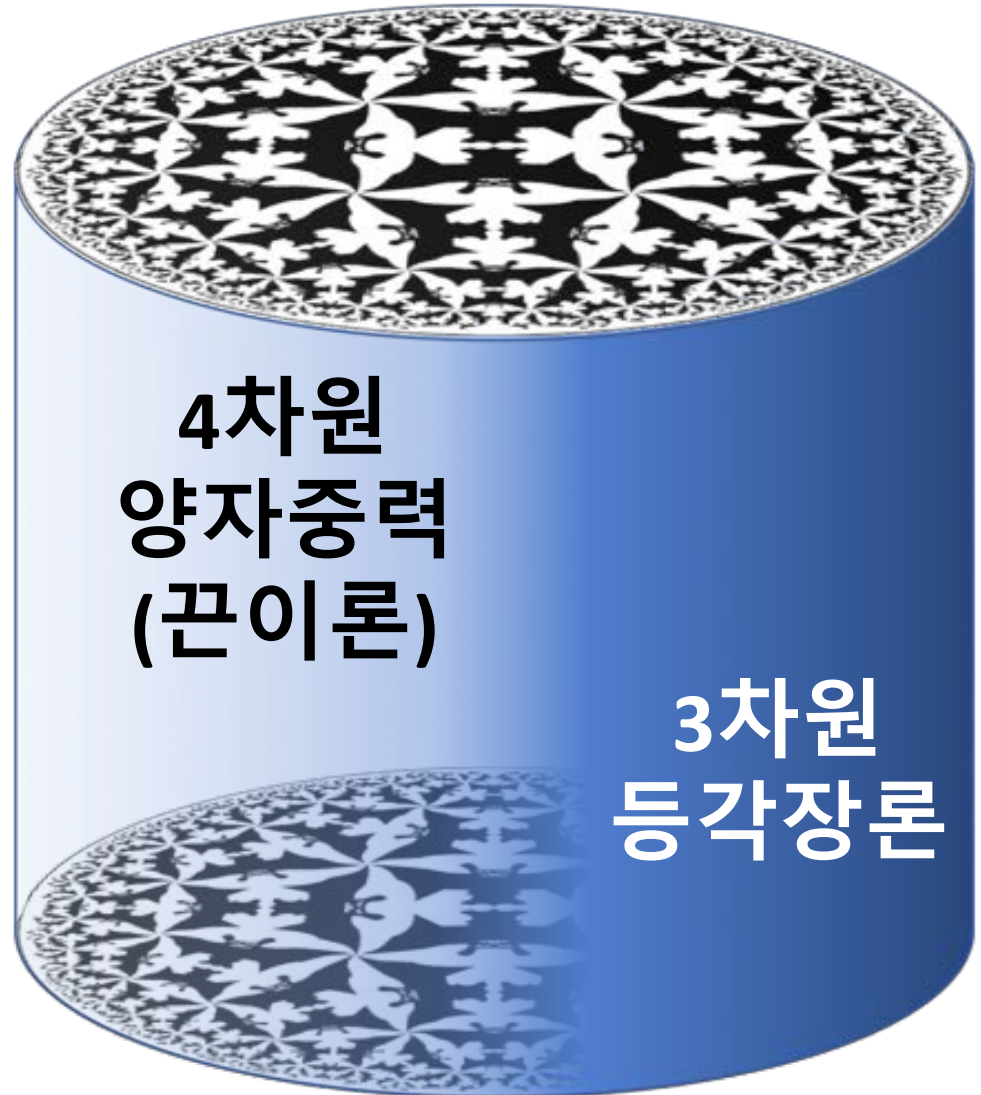
비파괴 검사



홀로그래피 이중성

**모든 물리량 사이에
일대일 대응성 존재**

- 강한 상호 작용
- 양자중력 미스터리
 - 양자 블랙홀
 - 특이점



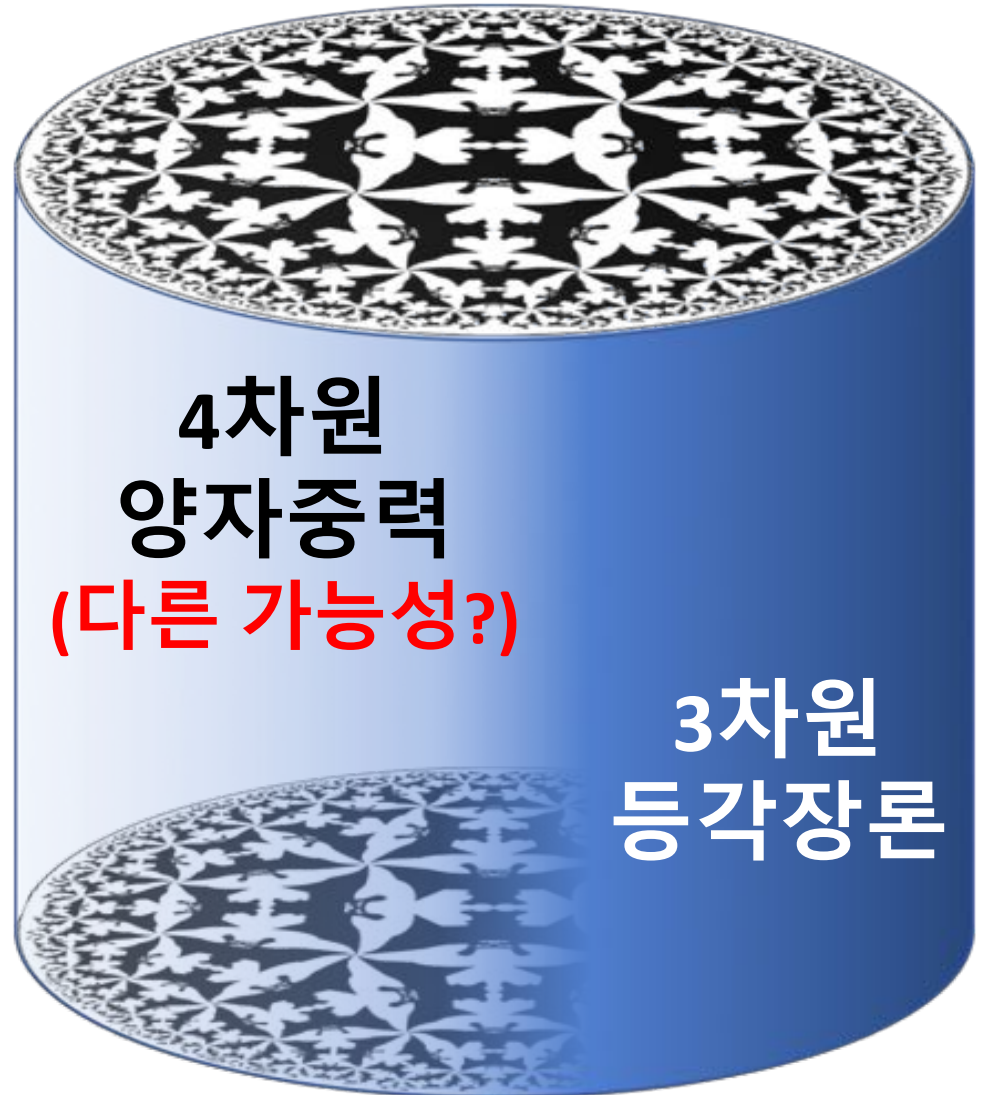
**4차원
양자중력
(끈이론)**

**3차원
등각장론**

홀로그래피 이중성

고차스핀
중력이론

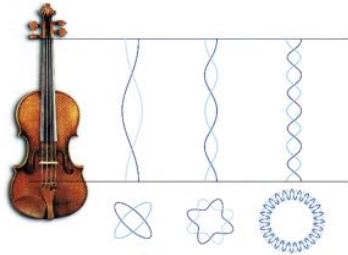
Higher Spin
Gravity



4차원
양자중력
(다른 가능성?)

3차원
등각장론

끈 이론



무한히 많은 입자

- 무한히 높은 **질량**
- 무한히 높은 **스핀**

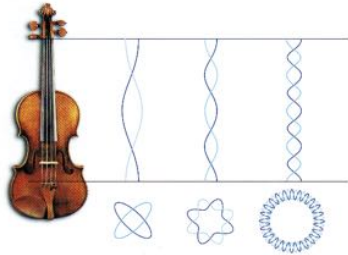
고차스핀 중력이론



무한히 많은 입자

- 모든 입자들이 **질량 없음**
- 무한히 높은 **스핀**
- **무한히 큰 대칭성**

끈 이론



자발적 대칭성 붕괴
(힉스 메카니즘)

고차스핀 중력이론



고차스핀 중력이론

- 말되는 양자 중력의 강력한 후보
- 기존의 기하학을 새로운 수학으로 확장
- 홀로그래피 이중성을 통해 3차원 특이현상 연구
- 끈이론에 대한 새로운 시각 제시



경청해 주셔서 감사합니다.