QUANTUM

FALL 2023

QUAN 2101, FALL 2023 RANGER LIU

UNIT 4: QUANTUM ROMANTICS

MATERIALS FOR LECTURE 1: FOUNDATIONS OF QR

UNIT 4 SCHEDULE

WEEK 1

TUESDAY	LECTURE 1: FOUNDATIONS OF QUANTUM ROMANTICS Problem Set 4.1 assigned
THURSDAY	PROBLEM SESSION Problem Set 4.1 due

WEEK 2

TUESDAY	LECTURE 1 REVIEW LECTURE 2: TIME EVOLUTION IN QR Problem Set 4.1 peer corrections assigned Problem Set 4.2 assigned
THURSDAY	QUIZ 4.1 ON LECTURE 1 PROBLEM SESSION Problem Set 4.1 peer corrections due Problem Set 4.2 due

WEEK 3

TUESDAY	LECTURE 2 REVIEW LECTURE 3: ENTANGLEMENT IN QR Problem Set 4.2 peer corrections assigned Problem Set 4.3 assigned
THURSDAY	QUIZ 4.2 ON LECTURE 2 PROBLEM SESSION Problem Set 4.2 peer corrections due Problem Set 4.3 due

WEEK 4

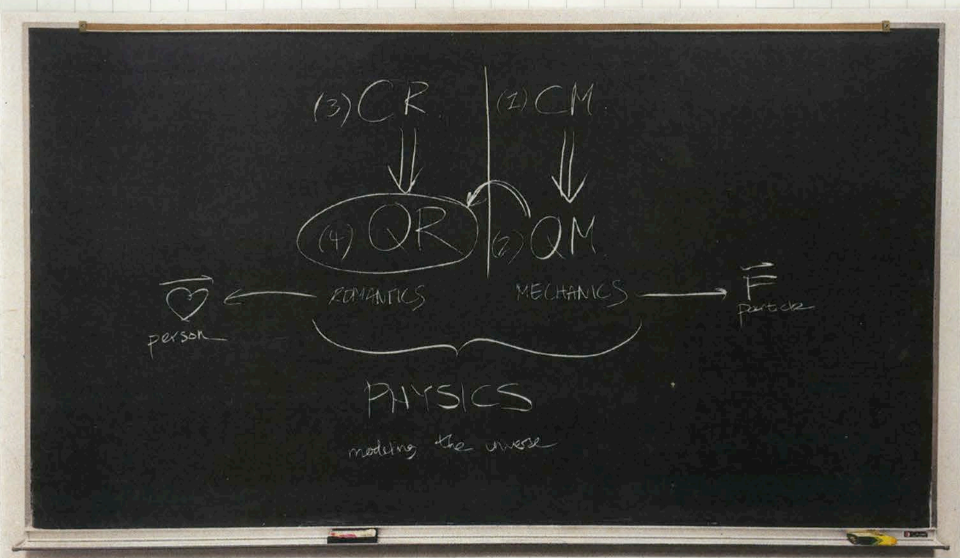
TUESDAY	UNIT 4 REVIEW Problem Set 4.3 peer corrections assigned
THURSDAY	UNIT 4 EXAM Problem Set 4.3 peer corrections due

LECTURE 1: FOUNDATIONS OF QUANTUM ROMANTICS

CONCEPTS, BASES, LQS (OPERATORS), PRINCIPLE PARADOXES

NOTES

I. INTRODUCTION.



QUANTUM ROMANTICS FOLLOWS AFTER CLASSICAL ROMANTICS,

QUANTUM MECHANICS FOLLOWS AFTER CLASSICAL MECHANICS.

ROMANTICS & MECHANICS ARE SUBFIELDS OF PHYSICS,

MODELING SPECIFIC BEHAVIORS OF THE UNIVERSE:

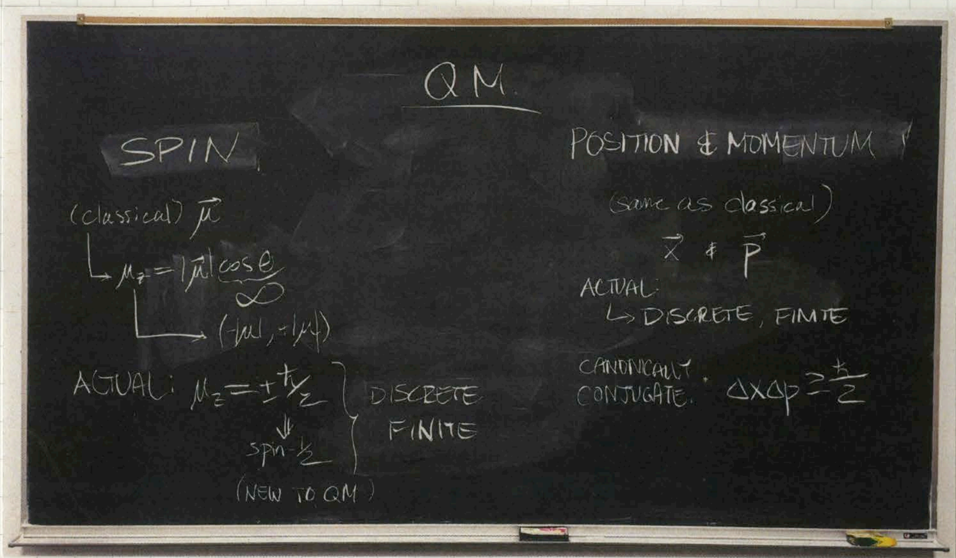
LOVE & DESIRE IN PERSONS, FORCE & MOTION IN PARTICLES.

QUANTUM ROMANTICS & QUANTUM MECHANICS SHARE MATHEMATICS,

WITH NOTABLE EXCEPTIONS.

NOTES.

II. CONCEPTUAL OVERVIEW.



2.1 QM REVIEW.

SPIN IS NEW (NOVEL), RELATED TO MAGNETIC MOMENT.

SPIN HAS FINITE POSSIBILITIES OF DISCRETE VALUES.

MAGNETIC MOMENT SHOULD HAVE INFINITE POSSIBILITIES WITHIN A CONTINUOUS RANGE OF VALUES, BUT IS FINITE & DISCRETE IN REALITY. HENCE, SPIN.

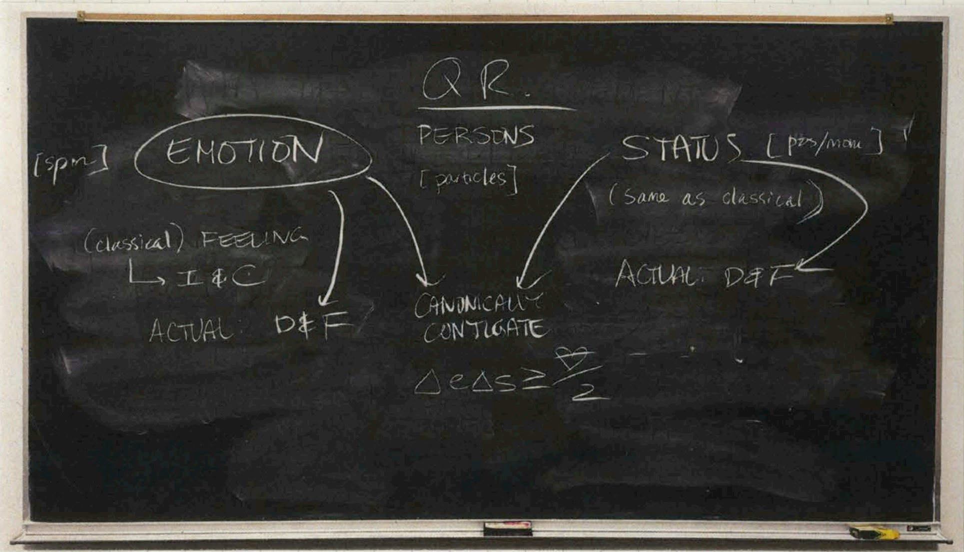
POSITION & MOMENTUM ARE (RE)NEW(ED).

THE SAME CONCEPTS NOW HAVE FINITE POSSIBILITIES OF DISCRETE VALUES.

POSITION & MOMENTUM ARE CANONICALLY CONJUGATE: SIMULTANEOUS KNOWLEDGE OF BOTH IS IMPOSSIBLE.

NOTES.

2.2 QM TO QR ANALOGY.



EMOTION IS NEW (NOVEL), RELATED TO FEELING.

EMOTION HAS FINITE POSSIBILITIES OF DISCRETE VALUES.

FEELING SHOULD HAVE INFINITE POSSIBILITIES
WITHIN A CONTINUOUS RANGE OF VALUES,
BUT IS FINITE & DISCRETE IN REALITY. HENCE, EMOTION.

STATUS IS (RE)NEW(ED).

THE SAME CONCEPT NOW HAS FINITE POSSIBILITIES OF DISCRETE VALUES.

EMOTION & STATUS ARE CANONICALLY CONJUGATE:
SIMULTANEOUS KNOWLEDGE OF BOTH IS IMPOSSIBLE.

NOTES.

WHY IS REALITY FINITE & DISCRETE?

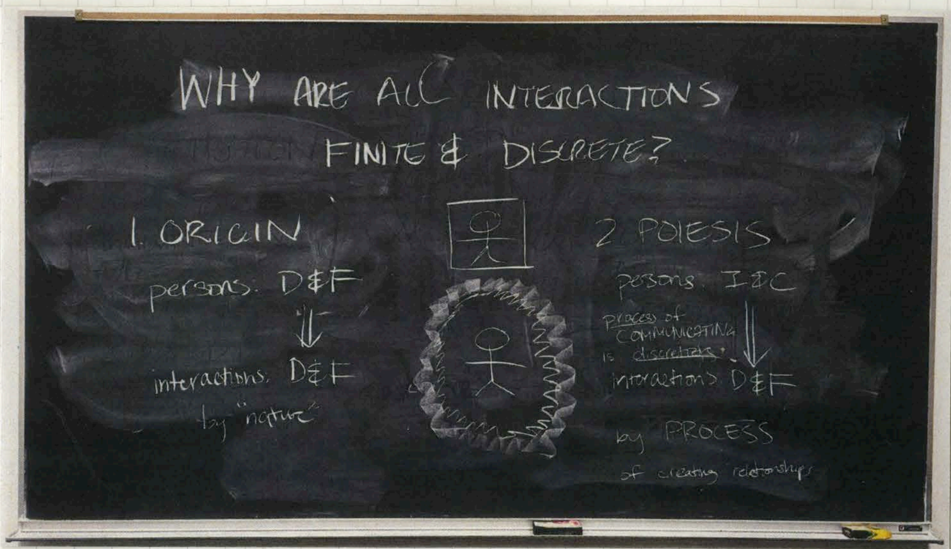
1. PARTICLES ARE FINITE & DISCRETE BY ORIGINAL NATURE.

2. PARTICLES EXIST IN AN INFINITE FIRMAMENT;

COMMUNICATION IS AN INHERENTLY DISCRETIZING PROCESS.

NOTES.

2.4 ONTOLOGICAL CAUSALITY IN QR.



IS THE TOTALITY OF MY LIVED EXPERIENCE

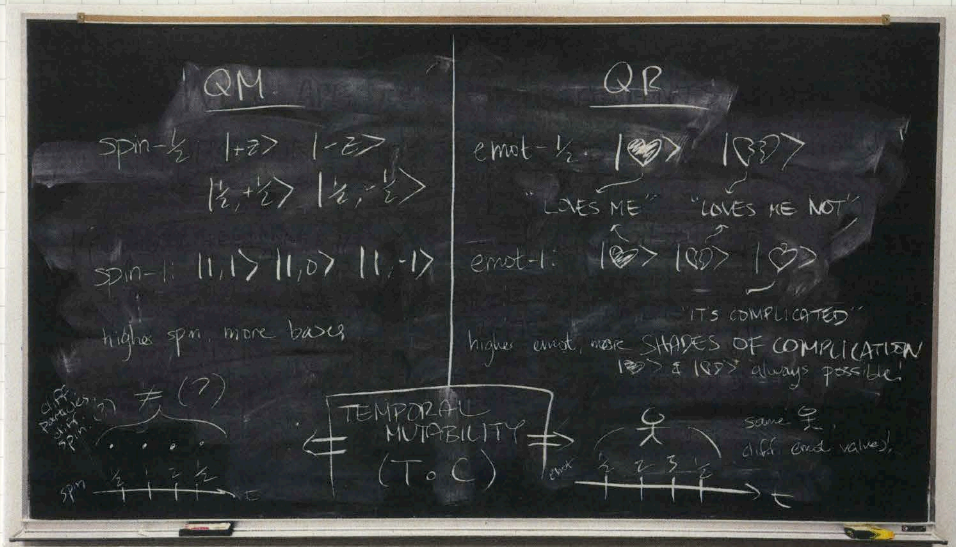
A CONTINUOUS & INFINITE THING,

ONLY IMPERFECTLY EXPRESSIBLE

THROUGH DISCRETE & FINITE EXTERNALIZATIONS?

NOTES.

III. EMOT STATE BASES.



FOR ALL EMOT VALUES, LOVES ME & LOVES ME NOT

ALWAYS FORM TWO ORTHOGONAL DIMENSIONS OF POSSIBLE MEASUREMENT.

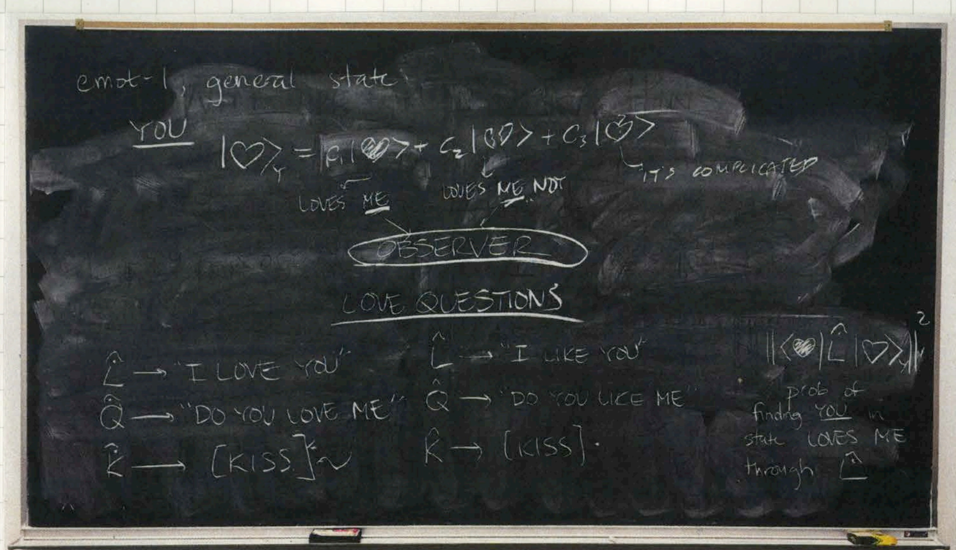
HIGHER EMOT VALUES HAVE MULTIPLE SHADES OF IT'S COMPLICATED,

SPLITTING INTO MULTIPLE ORTHOGONAL DIMENSIONS OF POSSIBLE MEASUREMENT.

EMOT VALUES CHANGE OVER TIME.

NOTES.

IV. LQS (OPERATORS IN QR).



4.1 INTRODUCTION TO LQS.

THE ONE-PERSON STATE OF YOU INVOKES ME, THE OBSERVER.

(THE CLASSICAL PARADOX OF EROS SEEPS INTO QUANTUM MATHEMATICS.)

MEASUREMENTS OF YOU ARE MADE BY ME THROUGH LOVE QUESTIONS:

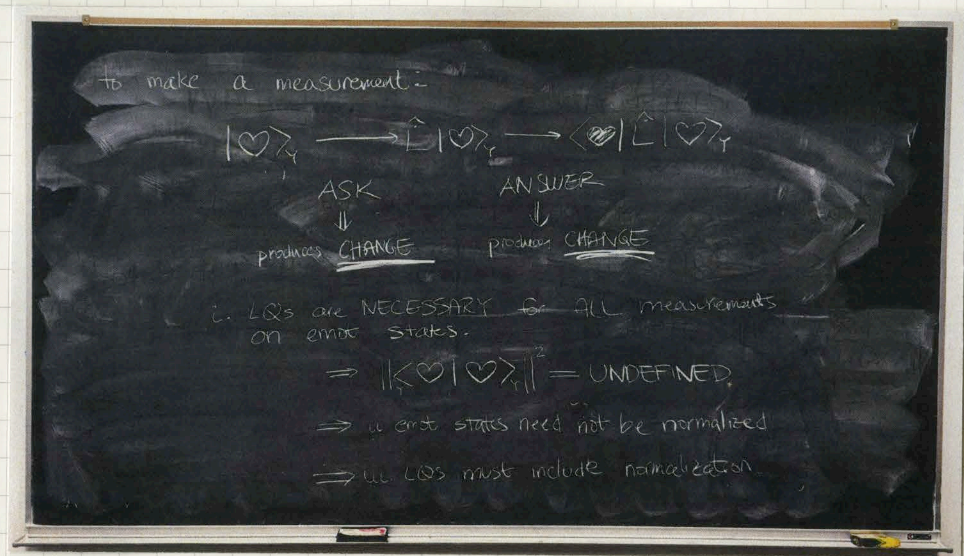
INTERACTIONS THAT TELL ME ABOUT THE EMOT STATE OF YOU.

I MODEL THE PROBABILITY OF FINDING YOU IN THE STATE LOVES ME

AS MEASURED THROUGH THE LOVE QUESTION I LOVE YOU.

NOTES.

4.2 THE PRINCIPLE PARADOX OF INTERROGATIVE NECESSITY



MEASUREMENT MUST BE MADE THROUGH AN ASKING

WHICH PROVOKES AN ANSWERING. HENCE, INTERROGATIVE NECESSITY.

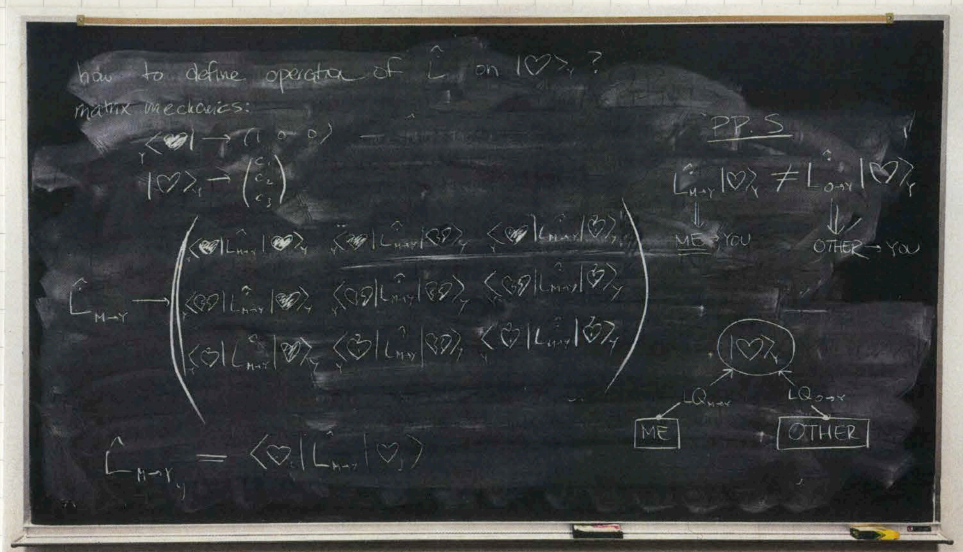
THE BEING ASKED, AND THE ANSWERING, PROVOKES CHANGE.

HENCE: PARADOX.

THE IDENTITY OPERATOR IS EXPERIMENTALLY MEANINGLESS.

NOTES.

4.3 THE PRINCIPLE PARADOX OF SUBJECTIVITY.



FOR EVERY YOU, THERE EXISTS A UNIQUE HILBERT-SOUL SPACE

OF EMOT STATE VECTORS OF YOU.

FOR EVERY ME — YOU PAIR

EVERY OBSERVER — OBSERVEE PAIR

EVERY LOVER — BELOVED PAIR

THERE EXISTS A UNIQUE OPERATOR SPACE

OF LOVE QUESTIONS BETWEEN ME & YOU.

NOTES.

PROBLEM SET 4.1

100 pts

+15 pts extra credit

SHOW YOUR WORK!

1. (10 pts) State a comparison that analogously illustrates the concept of infinite & continuous vs. finite & discrete.

Ex. all real numbers $\mathbb{R}$ (infinite & continuous)

vs.

a subset of integers $\mathbb{Z}$ (finite & discrete)

2. The state of an emot-1 person, YOU, is given by

$$|\heartsuit\rangle_Y = \frac{\sqrt{2}}{2}|\text{♥}\rangle_Y + \frac{3i}{4}|\text{💔}\rangle_Y + \frac{\sqrt{3}}{2}|\text{❣}\rangle_Y$$

a) (10 pts) Which of the following LQs in the operator space ME → YOU are already normalized?

i. $$\hat{L}_{M\to Y} \rightarrow \begin{pmatrix} \frac{4}{\sqrt{29}} & 0 & 0 \\ 0 & \frac{4}{\sqrt{29}} & 0 \\ 0 & 0 & \frac{4}{\sqrt{29}} \end{pmatrix}$$

ii. $$\hat{Q}'_{M\to Y} \rightarrow \begin{pmatrix} 2i & 3 & 0 \\ 0 & 4i & 3 \\ 3 & 0 & 3i \end{pmatrix}$$

iii. $$\hat{K}_{M\to Y} \rightarrow \begin{pmatrix} \frac{\sqrt{2}}{3\sqrt{3}} & -\frac{2}{3\sqrt{3}}i & 0 \\ \frac{2}{3\sqrt{3}}i & -\frac{4}{3\sqrt{3}} & \frac{2}{3}i \\ 0 & -\frac{2}{3}i & \frac{2}{3\sqrt{3}} \end{pmatrix}$$

2. (cont.)

b) (10 pts) Explain when normalization would be required & how it should be implemented.

3. Consider two observers, ALICE & BOB, whose strong-L LQs in the $\rightarrow$ YOU operator space are given by

$$\hat{L}_{A \to Y} \longrightarrow \begin{pmatrix} \frac{2\sqrt{2}}{\sqrt{27}} & \frac{4}{\sqrt{27}} i & 0 \\ -\frac{4}{\sqrt{27}} i & \frac{2\sqrt{2}}{\sqrt{27}} & \frac{6\sqrt{2}}{\sqrt{27}} \\ 0 & \frac{6\sqrt{2}}{\sqrt{27}} & \frac{2\sqrt{2}}{\sqrt{27}} \end{pmatrix}$$

$$\hat{L}_{B \to Y} \longrightarrow \begin{pmatrix} \frac{4\sqrt{2}}{\sqrt{37}} & 0 & \frac{8i}{3\sqrt{37}} \\ \frac{2\sqrt{2}}{3\sqrt{37}} i & 0 & \frac{4\sqrt{3}}{3\sqrt{37}} \\ \frac{4\sqrt{2}}{3\sqrt{37}} & \frac{4}{3\sqrt{37}} & \frac{2\sqrt{3}}{3\sqrt{37}} \end{pmatrix}$$

Use the same YOU state given in problem 2.

a) (5 pts) What is the probability of ALICE measuring YOU in the state LOVES ME through strong-L, *before* BOB measures YOU?

b) (5 pts) What is the probability of BOB measuring YOU in the state LOVES ME through strong-L, *before* ALICE measures YOU?

c) (5 pts) What is the probability of ALICE measuring YOU in the state LOVES ME through strong-L, *after* BOB measures YOU through strong-L?

d) (5 pts) What is the probability of BOB measuring YOU in the state LOVES ME through strong-L, *after* ALICE measures YOU through strong-L?

e) (5 pts) If ALICE wants to find YOU in the state LOVES ME, should she measure YOU through strong-L before or after BOB does?

f) (5 pts) If BOB wants to find YOU in the state LOVES ME, should he measure YOU through strong-L before or after ALICE does?

g) (5 pts) Why is strong-L defined differently for ALICE & BOB?

4. Strong-L & strong-Q in the ME → YOU operator space are given by

$$\hat{L}_{M\to Y} \longrightarrow \begin{pmatrix} \frac{\sqrt{3}}{9} & \frac{4}{9} & \frac{2\sqrt{3}}{9}i \\ \frac{2\sqrt{6}}{9} & \frac{2}{3} & \frac{1}{9} \\ 0 & \frac{2}{9} & \frac{\sqrt{3}}{9} \end{pmatrix}$$

$$\hat{Q}_{M\to Y} \longrightarrow \begin{pmatrix} \frac{4}{39} & \frac{20}{39\sqrt{2}}i & -\frac{20}{39\sqrt{2}}i \\ \frac{20}{39} & 0 & \frac{20\sqrt{3}}{39\sqrt{2}} \\ \frac{20}{39} & \frac{20}{39\sqrt{2}}i & \frac{4\sqrt{3}}{39\sqrt{2}} \end{pmatrix}$$

Using the same YOU state given in problem 2, what is the probability of finding YOU in the state LOVES ME through

a) (5 pts) strong-L?

b) (5 pts) strong - Q ?

c) (5 pts) strong - L followed by strong - Q ?

d) (5 pts) strong - Q followed by strong - L ?

e) (5 pts) If I want to find YOU in the state LOVES ME, which LQ(s) should I use and in what order?

5. (5 pts) Write 2-3 sentences from your perspective defending either position on ontological causality (discretization by origin or discretization by poiesis), as applied to QM, QR, or both.

EXTRA CREDIT (10 pts)

Consider the norm-factored LQ in the operator space ME → YOU given by

$$\hat{LQ}_{M \to Y} \longrightarrow \begin{pmatrix} \sqrt{2} & 0 & \sqrt{3} \\ 1 & i & \sqrt{3}/2 \\ 0 & i & 0 \end{pmatrix}$$

Using the YOU state from problem 2, what would be the normalization factor? What is the matrix representation of the normalited LQ?

EXTRA EXTRA CREDIT (1 – 5 pts)
Name up to five other common LQs not listed in lecture. (1 pt per valid LQ)

SUPPLEMENTARY NOTES

QUANTUM ROMANTICS.

YOU

$|\varheartsuit\rangle_Y \longrightarrow$ "LOVES ME" $\begin{pmatrix}1\\0\\0\end{pmatrix}$

$|\heartsuit\!\!/\rangle_Y \longrightarrow$ "LOVES ME NOT" $\begin{pmatrix}0\\1\\0\end{pmatrix}$

$|\heartsuit^{?}\rangle_Y \longrightarrow$ "IT'S COMPLICATED" $\begin{pmatrix}0\\0\\1\end{pmatrix}$

$$|\heartsuit\rangle_Y = c_1|\varheartsuit\rangle_Y + c_2|\heartsuit\!\!/\rangle_Y + c_3|\heartsuit^{?}\rangle_Y \quad \begin{pmatrix}c_1\\c_2\\c_3\end{pmatrix}$$

emot-I states.

ME

$\hat{L}_M \longrightarrow$ " I LOVE YOU" $\hat{L}_M \longrightarrow$ " I LIKE YOU"

$\hat{Q}_M \longrightarrow$ " DO YOU LOVE ME" $\hat{Q}_M \longrightarrow$ " DO YOU LIKE ME"

$\hat{K}_M \longrightarrow$ [KISS] ~ $\hat{K}_M \longrightarrow$ [KISS] ·

love questions (operators).

ME → YOU

$\| {}_Y\langle\varheartsuit|\hat{L}_{M\to Y}|\heartsuit\rangle_Y \|^2 = ?$ $\| {}_Y\langle\varheartsuit|\hat{L}_{M\to Y}|\heartsuit\rangle_Y \|^2 = ?$

$\| {}_Y\langle\varheartsuit|\hat{Q}_{M\to Y}|\heartsuit\rangle_Y \|^2 = ?$ $\| {}_Y\langle\varheartsuit|\hat{Q}_{M\to Y}|\heartsuit\rangle_Y \|^2 = ?$

$\| {}_Y\langle\varheartsuit|\hat{K}_{M\to Y}|\heartsuit\rangle_Y \|^2 = ?$ $\| {}_Y\langle\varheartsuit|\hat{K}_{M\to Y}|\heartsuit\rangle_Y \|^2 = ?$

$$\hat{LQ}_{M\to Y\, i,j} = \langle\heartsuit_i|\hat{LQ}_{M\to Y}|\heartsuit_j\rangle$$

measured probabilities.

<u>PRINCIPLE PARADOXES OF QR.</u>

1. THE PRINCIPLE PARADOX OF <u>INTERROGATIVE NECESSITY.</u> (PP. IN)

$$\| {}_Y\langle \heartsuit | \heartsuit \rangle_Y \|^2 = \text{UNDEFINED}$$

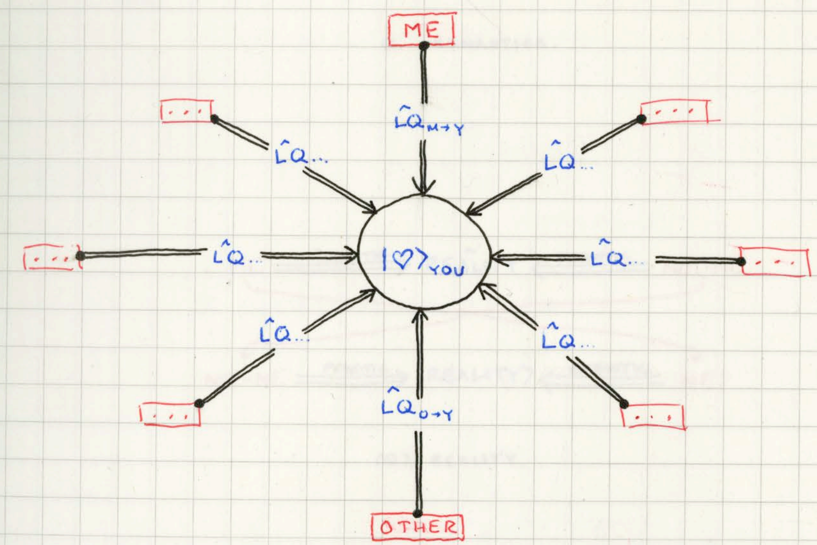
(the identity operator is experimentally meaningless.)

i. LQs are necessary for ALL measurements of emot states.

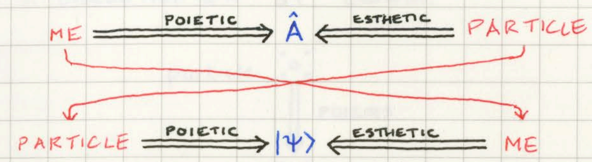
ii. emot states need not be normalized.

iii. asked states must be normalized before calculating probability.

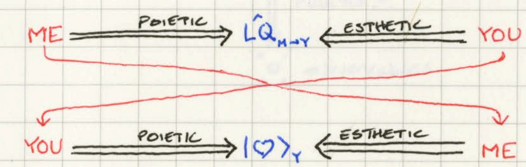
2. THE PRINCIPLE PARADOX OF SUBJECTIVITY. (PP. IN)



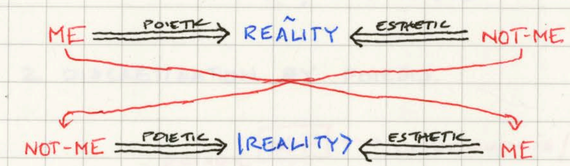
QUANTUM SEMIOTICS.



Q. MECHANICS.



Q. ROMANTICS.



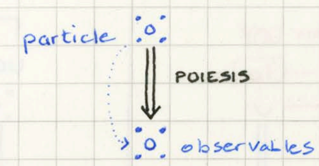
(Q.) REALITY.

ONTOLOGICAL CAUSALITY.

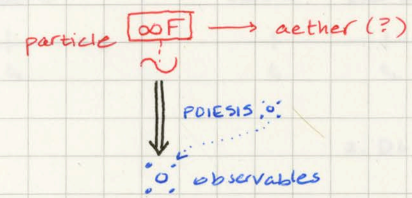
WHY IS REALITY ∷ AND O ?

QM.

1. DISCRETIZATION BY ORIGIN.

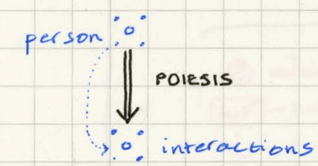


2. DISCRETIZATION BY POIESIS.

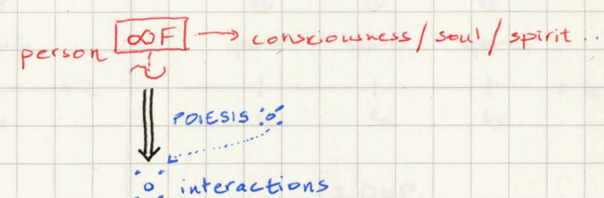


QR.

1. DISCRETIZATION BY ORIGIN.

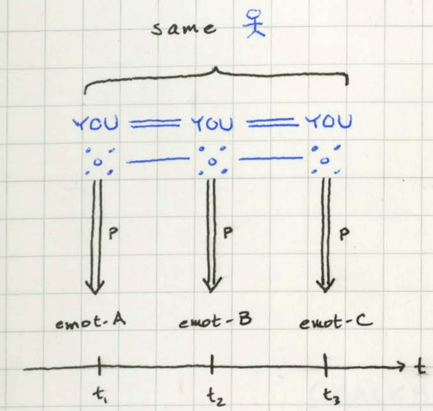


2. DISCRETIZATION BY POIESIS.

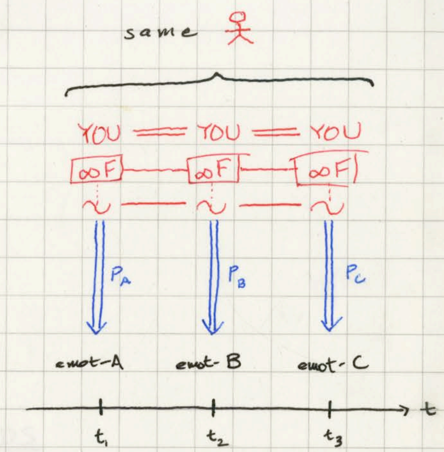


TEMPORAL MUTABILITY (THEORY OF CHANGE).

QR.

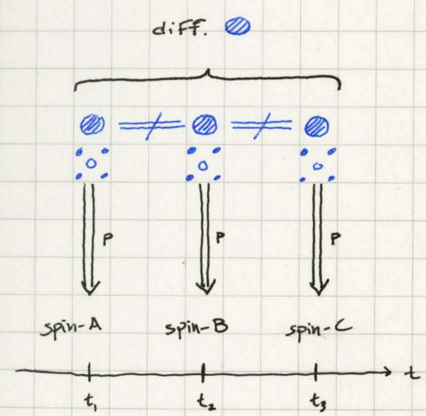


1. DbO.

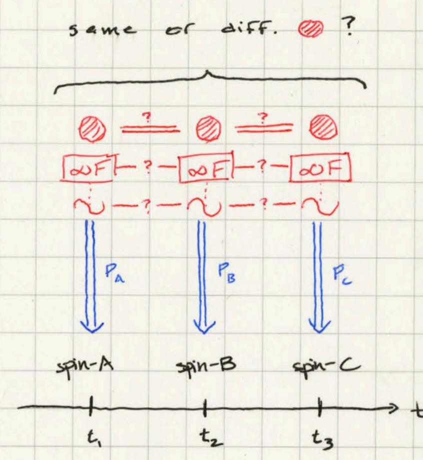


2. DbP.

QM.

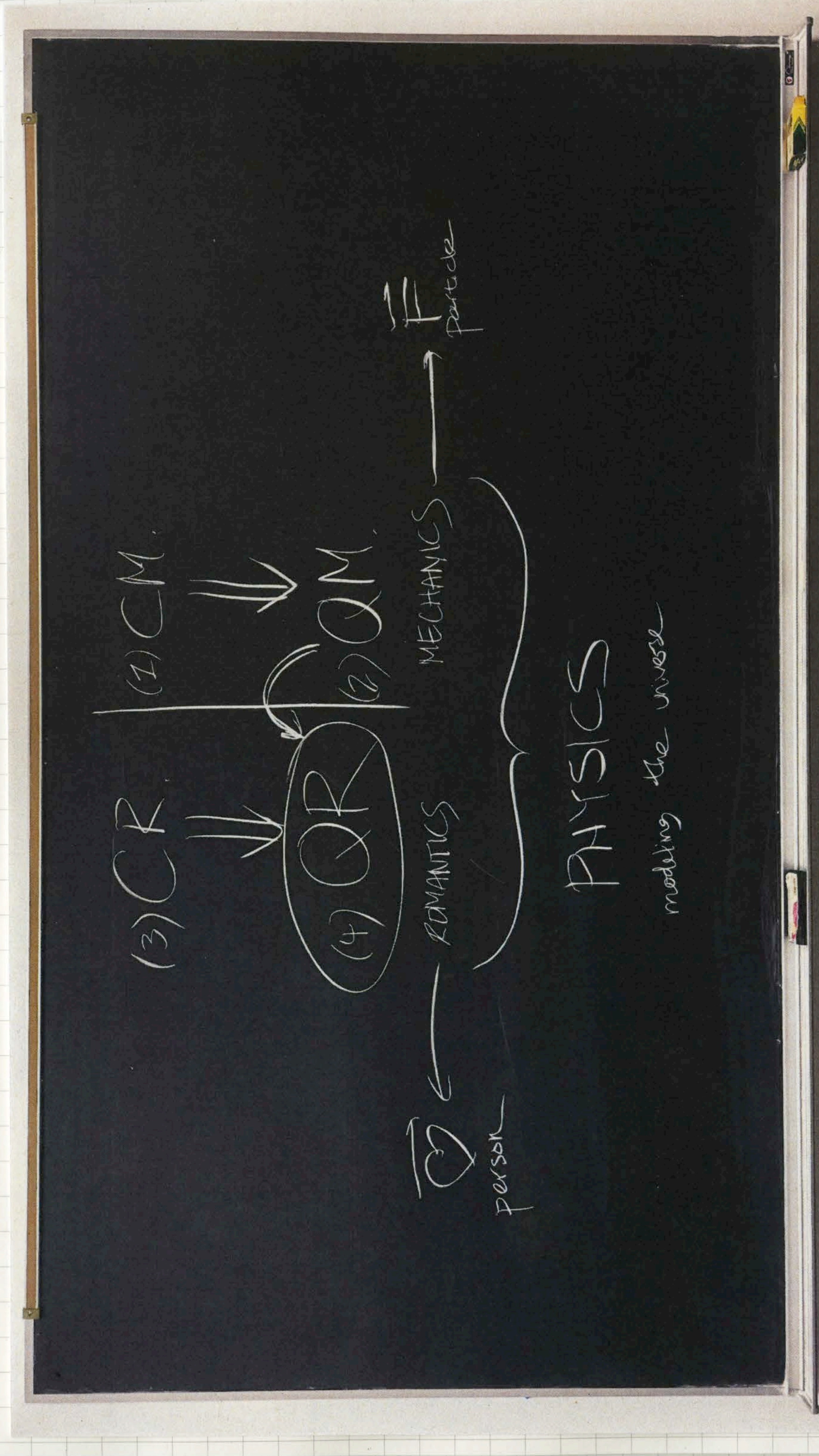


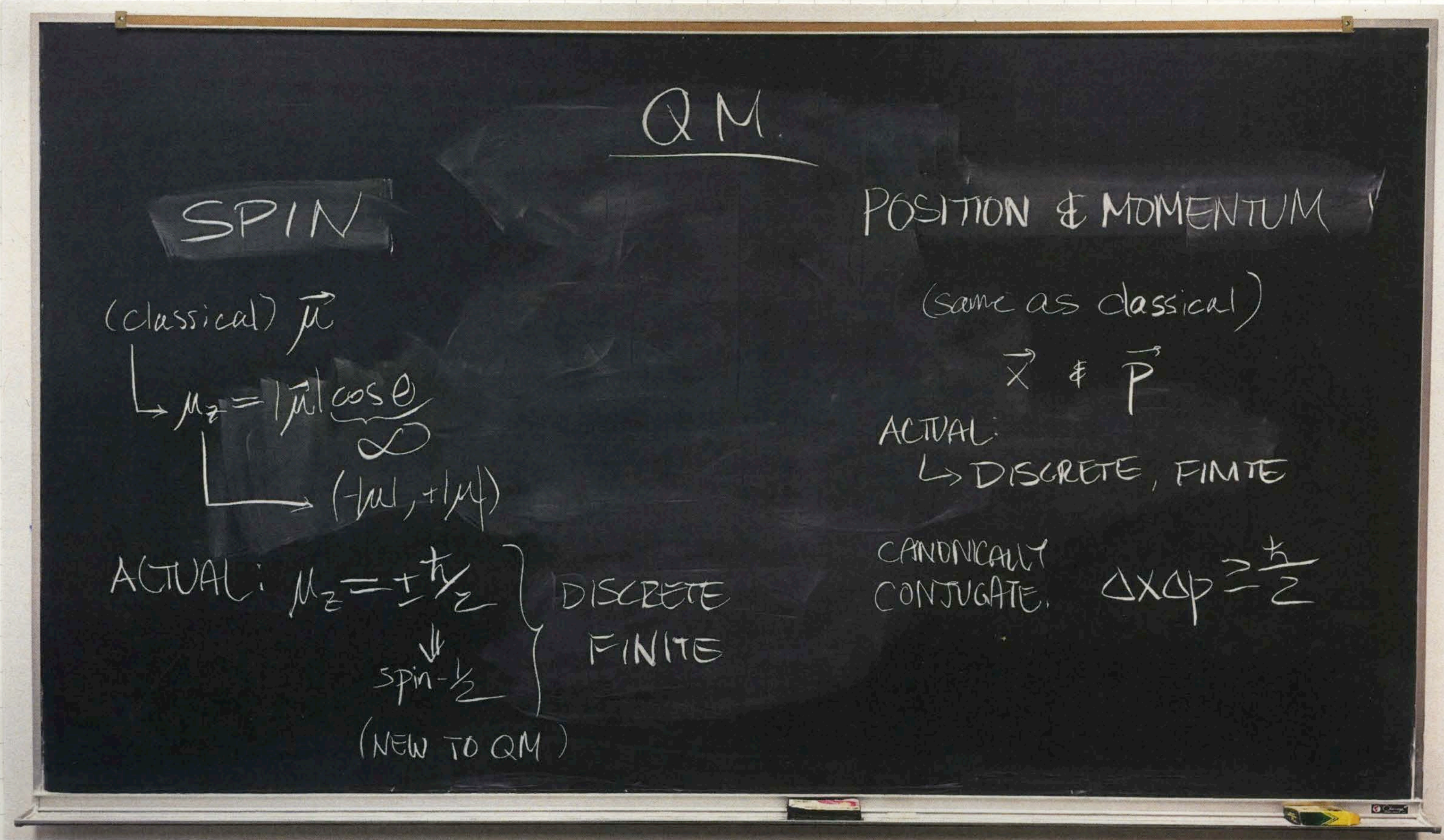
1. DbO.

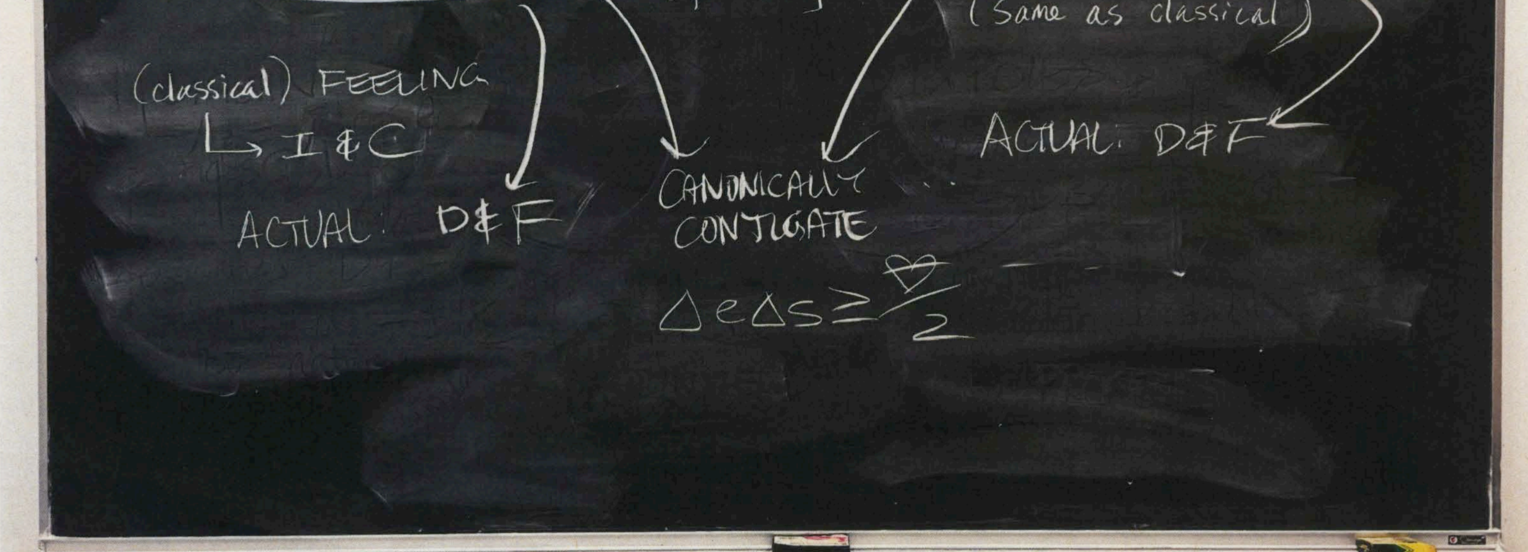


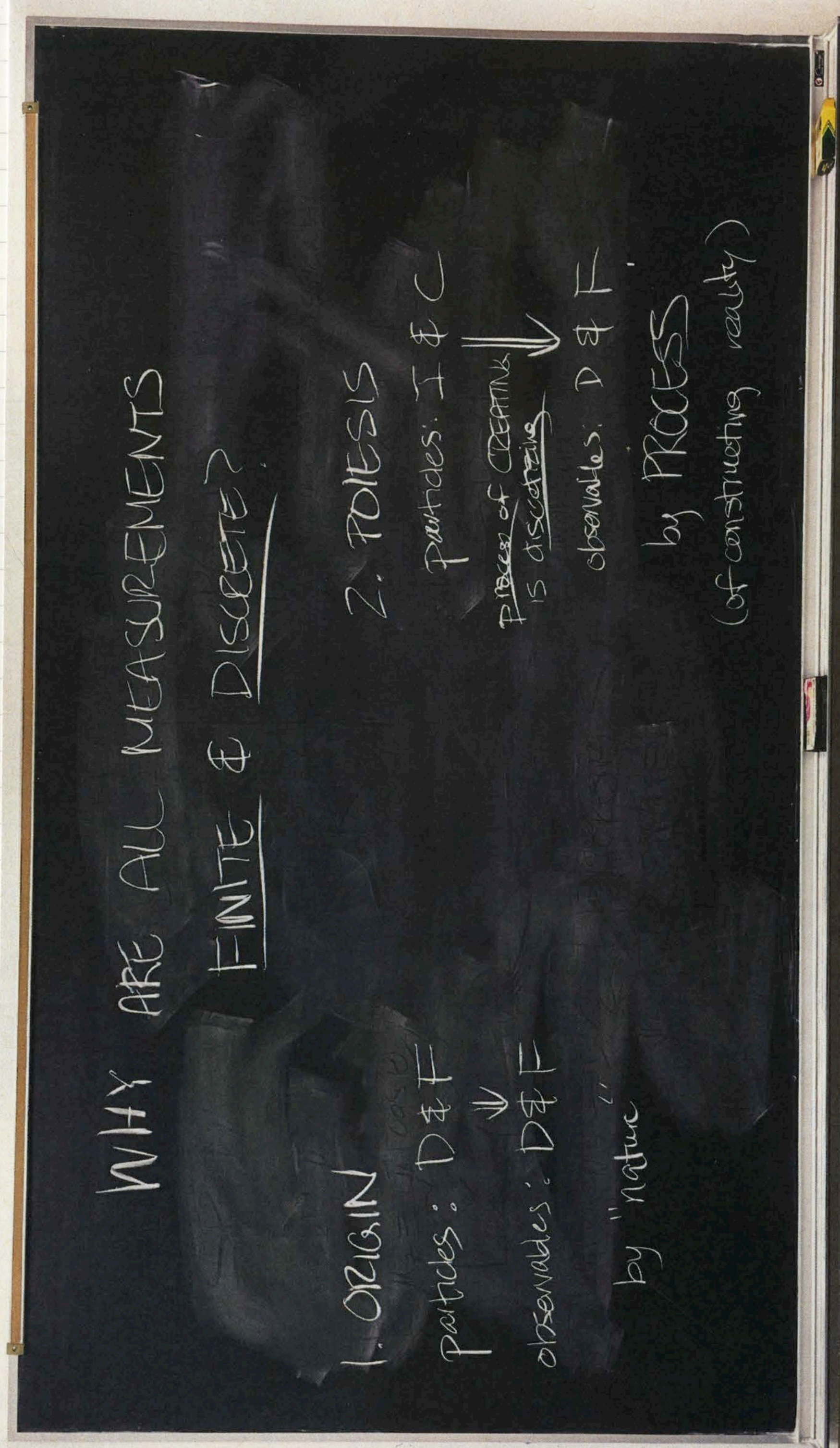
2. DbP.

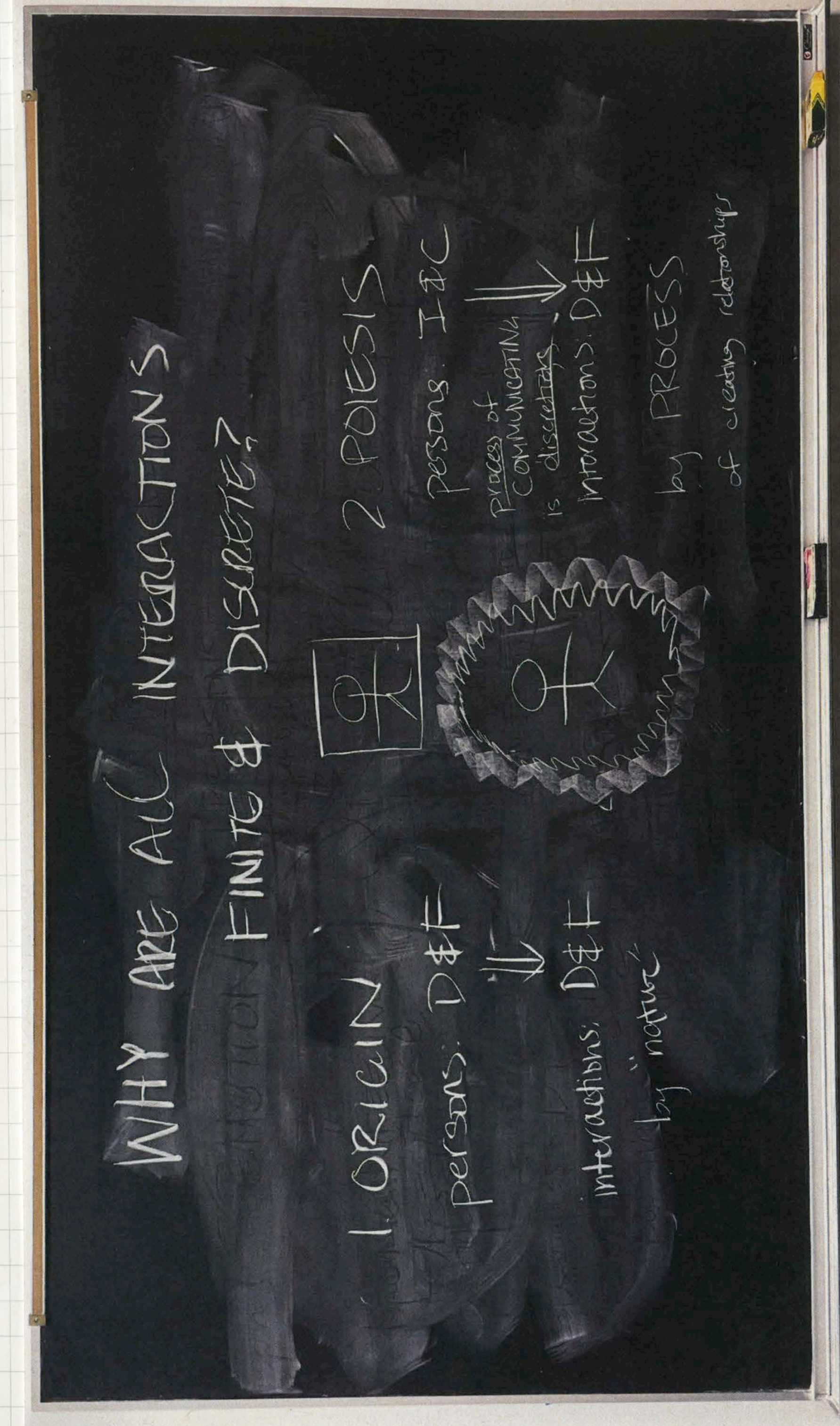
CHALKBOARDS

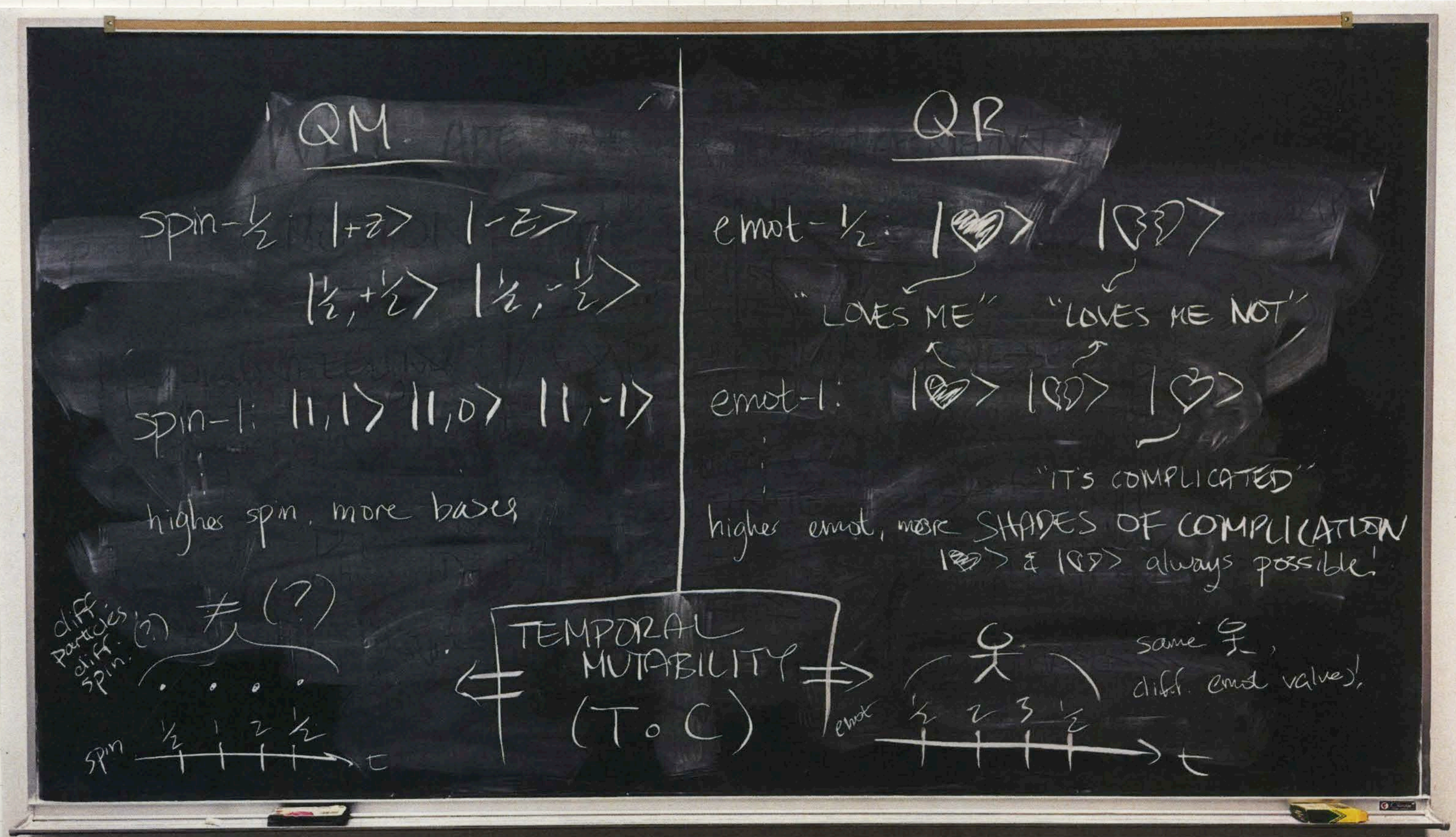

(1) CM.
(2) QM.
(3) CR.
(4) QR
MECHANICS
ROMANTICS
PHYSICS
modelling the universe
person
particle

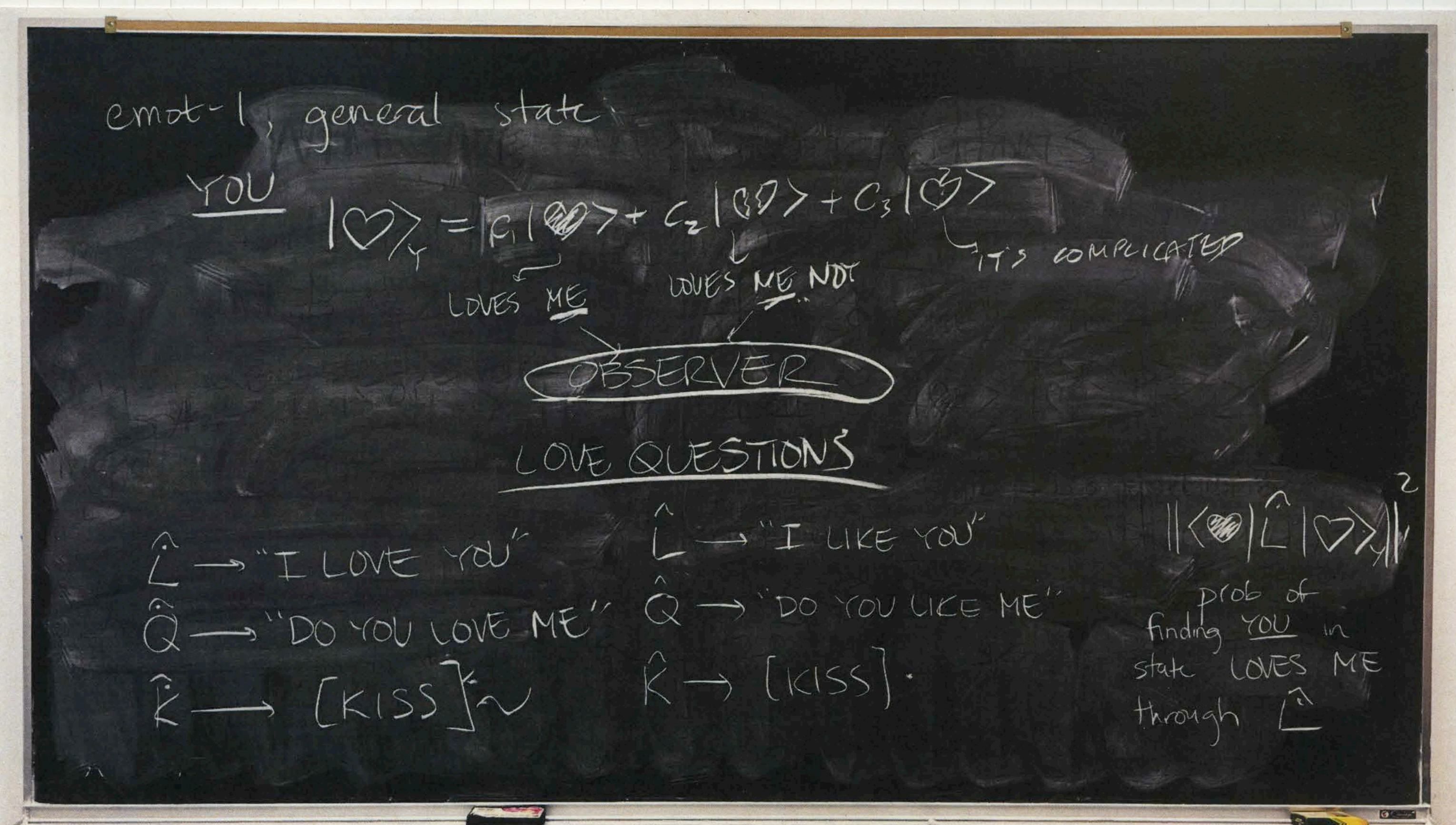

QM.
SPIN
(classical) μ⃗
↳ μz = |μ⃗| cos θ
∞
(−|μ|, +|μ|)
ACTUAL: μz = ±ℏ/2
⇓
spin-½
(NEW TO QM)
DISCRETE
FINITE
POSITION & MOMENTUM
(same as classical)
x⃗ & p⃗
ACTUAL:
↳ DISCRETE, FINITE
CANONICALLY
CONJUGATE.
ΔxΔp ≥ ℏ/2

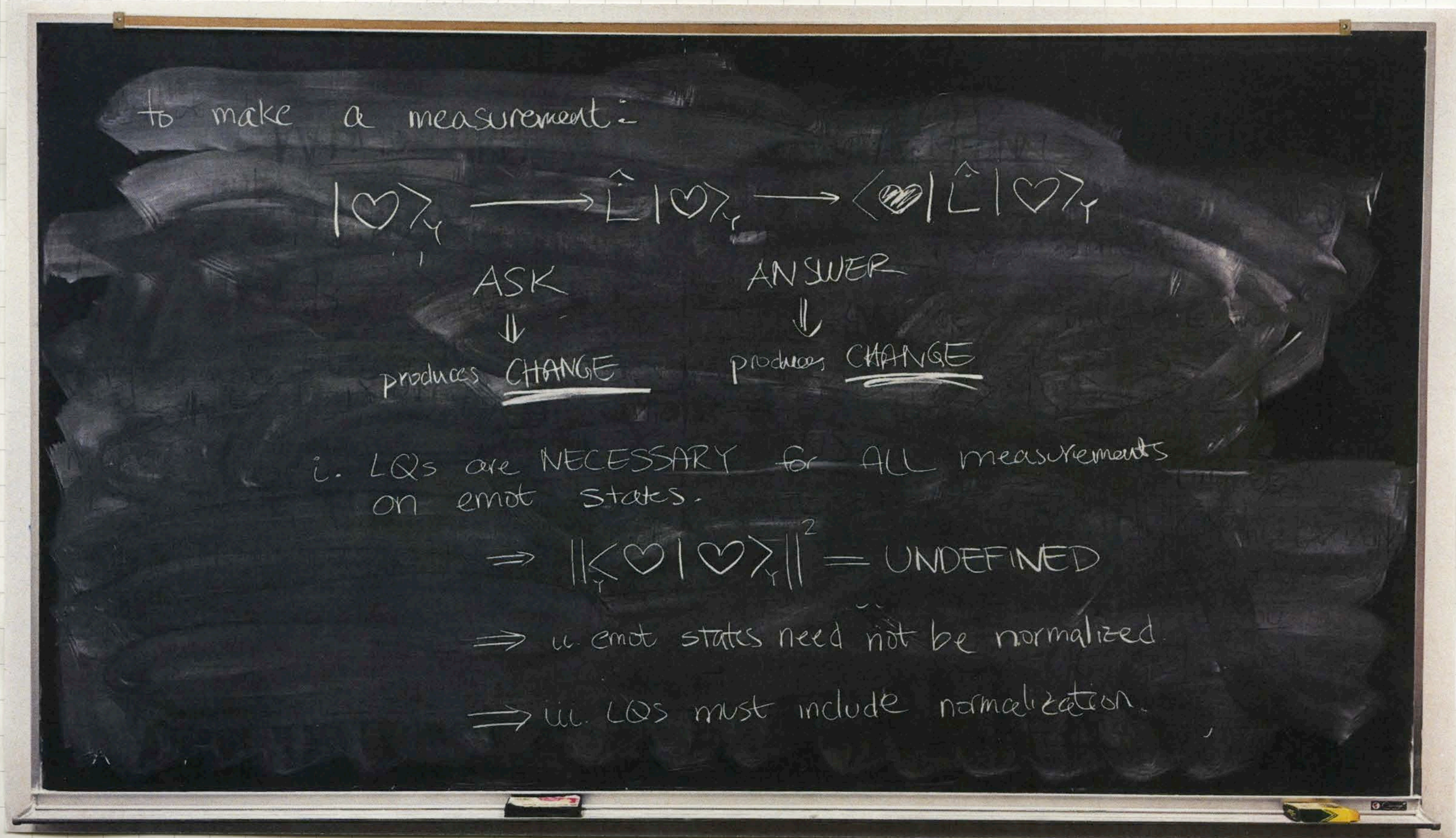

QR.
[spin]
EMOTION
(classical) FEELING
↳ I & C
ACTUAL: D&F
PERSONS
[particles]
CANONICALLY
CONJUGATE
ΔeΔs ≥ ♡/2
STATUS [pos/mom]
(same as classical)
ACTUAL: D&F

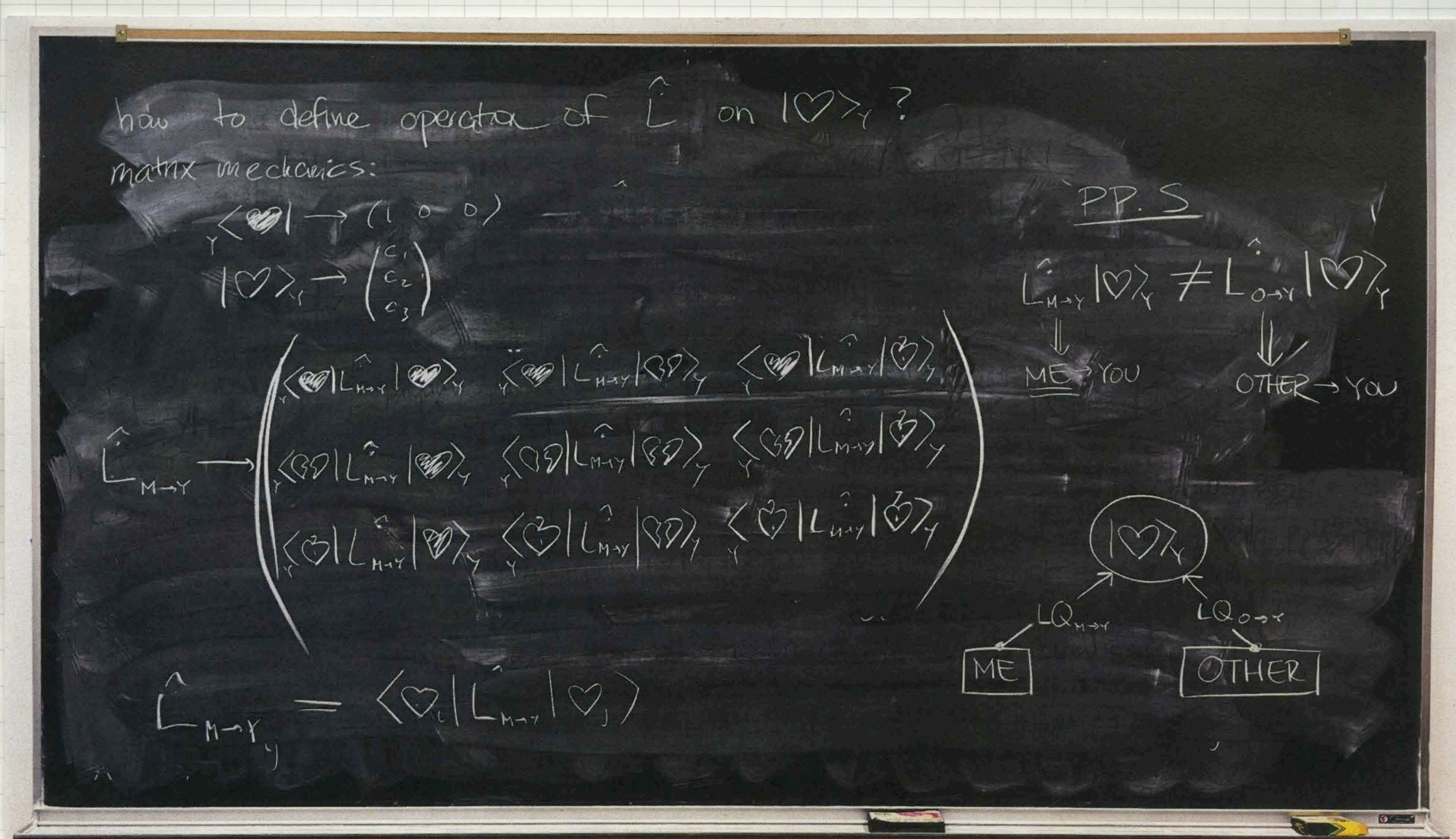

WHY ARE ALL MEASUREMENTS
FINITE & DISCRETE?
1. ORIGIN
particles: D&F
⇓
observables: D&F
by "nature"
2. POIESIS
particles: I&C
process of CREATING
is discretizing
⇓
observables: D&F
by PROCESS
(of constructing reality)


WHY ARE ALL INTERACTIONS
FINITE & DISCRETE?
1. ORIGIN
persons: D&F
⇓
interactions: D&F
by "nature"
2. POIESIS
persons: I&C
process of COMMUNICATING
is discretizing
⇓
interactions: D&F
by PROCESS
of creating relationships


QM
spin-½: |+z⟩ |−z⟩
|½, +½⟩ |½, −½⟩
spin-1: |1,1⟩ |1,0⟩ |1,−1⟩
higher spin, more bases
diff particles diff spin
spin
QR
emot-½:
"LOVES ME"
"LOVES ME NOT"
emot-1:
"IT'S COMPLICATED"
higher emot, more SHADES OF COMPLICATION
always possible!
TEMPORAL MUTABILITY
(T.o.C)
same
diff. emot values!
emot
t


emot-1, general state
YOU
LOVES ME
LOVES ME NOT
IT'S COMPLICATED
OBSERVER
LOVE QUESTIONS
L̂ → "I LOVE YOU"
Q̂ → "DO YOU LOVE ME"
K̂ → [KISS]
L̂ → "I LIKE YOU"
Q̂ → "DO YOU LIKE ME"
K̂ → [KISS].
prob of finding YOU in state LOVES ME through L̂


to make a measurement:
|♡⟩_Y ⟶ L̂|♡⟩_Y ⟶ ⟨♡|L̂|♡⟩_Y
ASK
produces CHANGE
ANSWER
produces CHANGE
i. LQs are NECESSARY for ALL measurements on emot states.
⇒ ||_Y⟨♡|♡⟩_Y||² = UNDEFINED
⇒ ii. emot states need not be normalized
⇒ iii. LQs must include normalization.


how to define operation of L̂ on |♡⟩_Y ?
matrix mechanics:
_Y⟨♡| → (1 0 0)
|♡⟩_Y → (c₁ c₂ c₃)
L̂_{M→Y} →
P.P.S
L̂_{M→Y}|♡⟩_Y ≠ L̂_{O→Y}|♡⟩_Y
ME → YOU
OTHER → YOU
|♡⟩_Y
LQ_{M→Y}
LQ_{O→Y}
ME
OTHER
L̂_{M→Y ij} = ⟨♡_i|L̂_{M→Y}|♡_j⟩

FURTHER READING.

CM.

Fundamentals of Physics, Halliday, Resnick, & Walker. 11^{th} Edition, 2018.

Classical Mechanics, John R. Taylor. 2005.

QM.

A Modern Approach to Quantum Mechanics, John S. Townsend. 2^{nd} Edition, 2013.

Principles of Quantum Mechanics, R. Shankar. 2^{nd} Edition, 1994.

CR.

Eros the Bittersweet, Anne Carson. 1986.

Love: A Sketch, Niklas Luhmann. 2010.

Classical Romantics: A Modern Approach, RANG, Sessell, & Kou. 5^{th} Edition, 2021.

QR.

Discretizing the Infinite, Ranger Liu. 2023.

Introduction to Quantum Romantics, RANG. 2^{nd} Edition, 2023.

Quantum Semiotics for Physicists, Y.R.L. 2022.