Title: A possible quantum gravity observation. Cosmic rays from Planck stars: black holes decay via tunneling.

Date: Jul 06, 2016 04:00 PM

URL: http://pirsa.org/16070003

Abstract: The possibility of observing quantum gravitational phenomena, viewed as remote until not long ago, is increasingly considered to be plausible. A potentially observable phenomenon is the decay of black holes via a quantum gravitational tunneling akin to standard nuclear decay. Loop quantum gravity can be used to compute the corresponding lifetime. This could be much shorter than the Hawking radiation time, rendering the effect astrophysically relevant. Preliminary estimates indicate that centimeter-size primordial black holes should be exploding today and predict impulsive high energy as well as microwave signals tantalizing similar to the Fast Radio Bursts recently observed by the Areceibo and Parkes radio telescopes. The predicted signal has a characteristic distance/frequency relation which will allow to test the Planck star hypotheses in the near future.

A QUANTUM GRAVITY CALCULATION FROM A TO Z

- VIDOTTO, CR : 1401.6562
- HAGGARD, CR: 1407.0989
- CHRISTODOULOU SPEZIALE, VILENSKY, CR: 1605.05268
- BARRAU, VIDOTTO, CR : 1409.4031
- D'AMBROSIO, CHRISTODOULOU: to appear

I. THE THEORY

II. THE PHYSICAL PROBLEM

III. THE MODEL

IV. SETTING-UP THE CALCULATION

V. QUANTUM AMPLITUDE

VI. SCALING ⇒ PREDICTION

VII. ASTROPHYSICS.

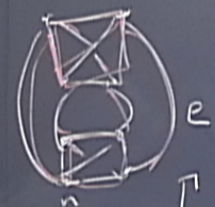
I THEORY CLQG : $(\mathcal{H}, \mathcal{A}, \mathcal{W})$

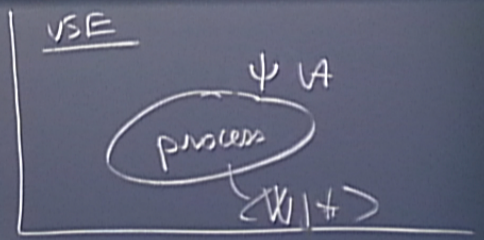
$\mathcal{H} = \lim_{\Gamma \to \infty} \mathcal{H}_\Gamma = L_2\left[SU(2)^L / SU(2)^N\right] \ni \psi(h_e)$

$A : \{A_\Gamma\} \Rightarrow h_e, \vec{L}_e \Leftarrow$ "physical" e : 2-complex.

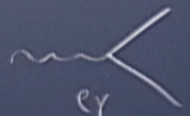
$\mathcal{W} = \lim_{e \to \infty}$ $W_e(h_e) = \int_{SU(2)} dh_{ve} \prod_f \delta(h_f) \prod_v A_v(h_e)$

$A_v(h_e) = \int_{SL(2,\mathbb{C})} dg_{ve} \prod_f \sum_j (2j+1) D^j_{mn}(h_e) D^{j,j}_{jm\,in}(g_e \bar{g}_e)$



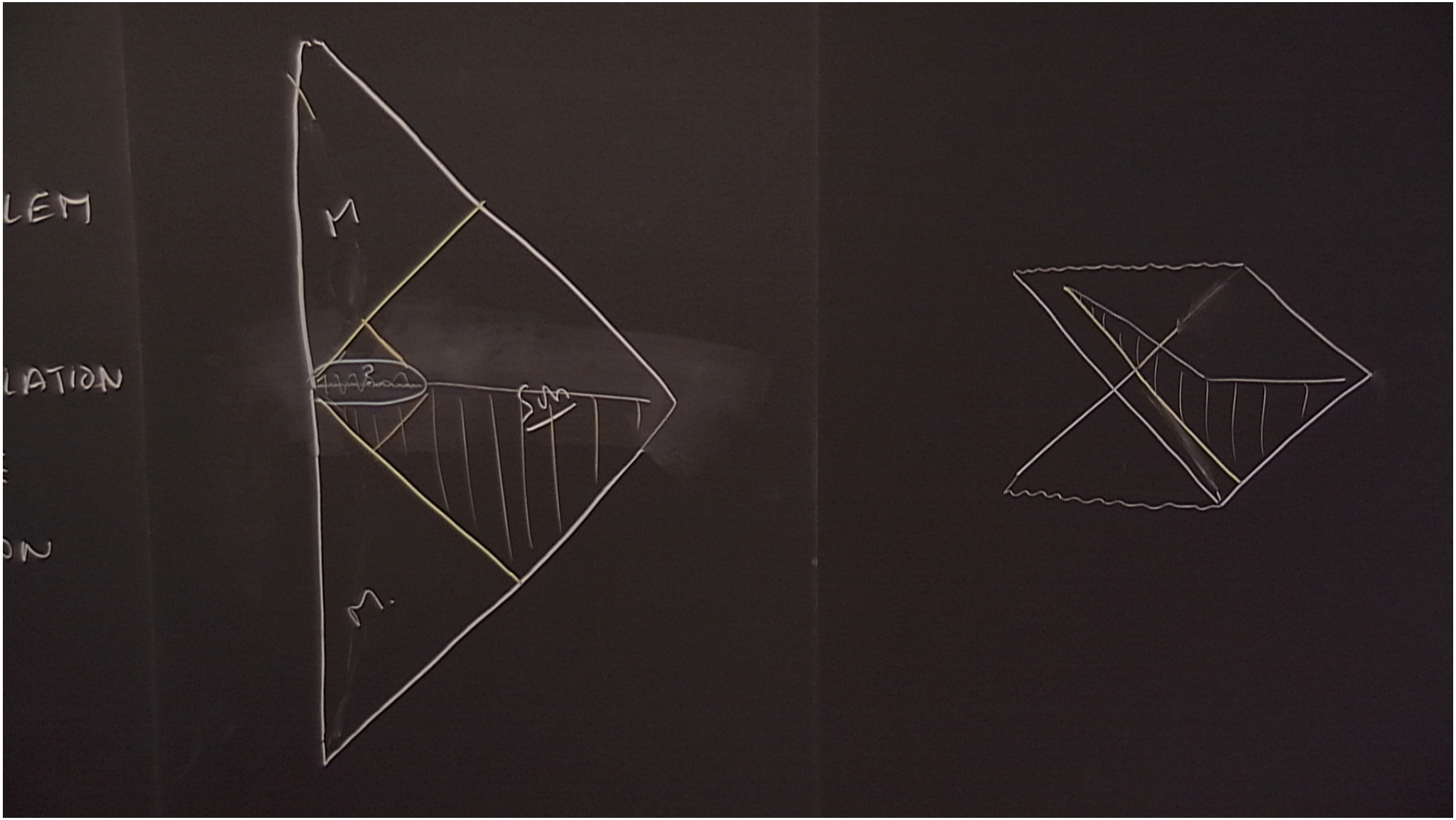


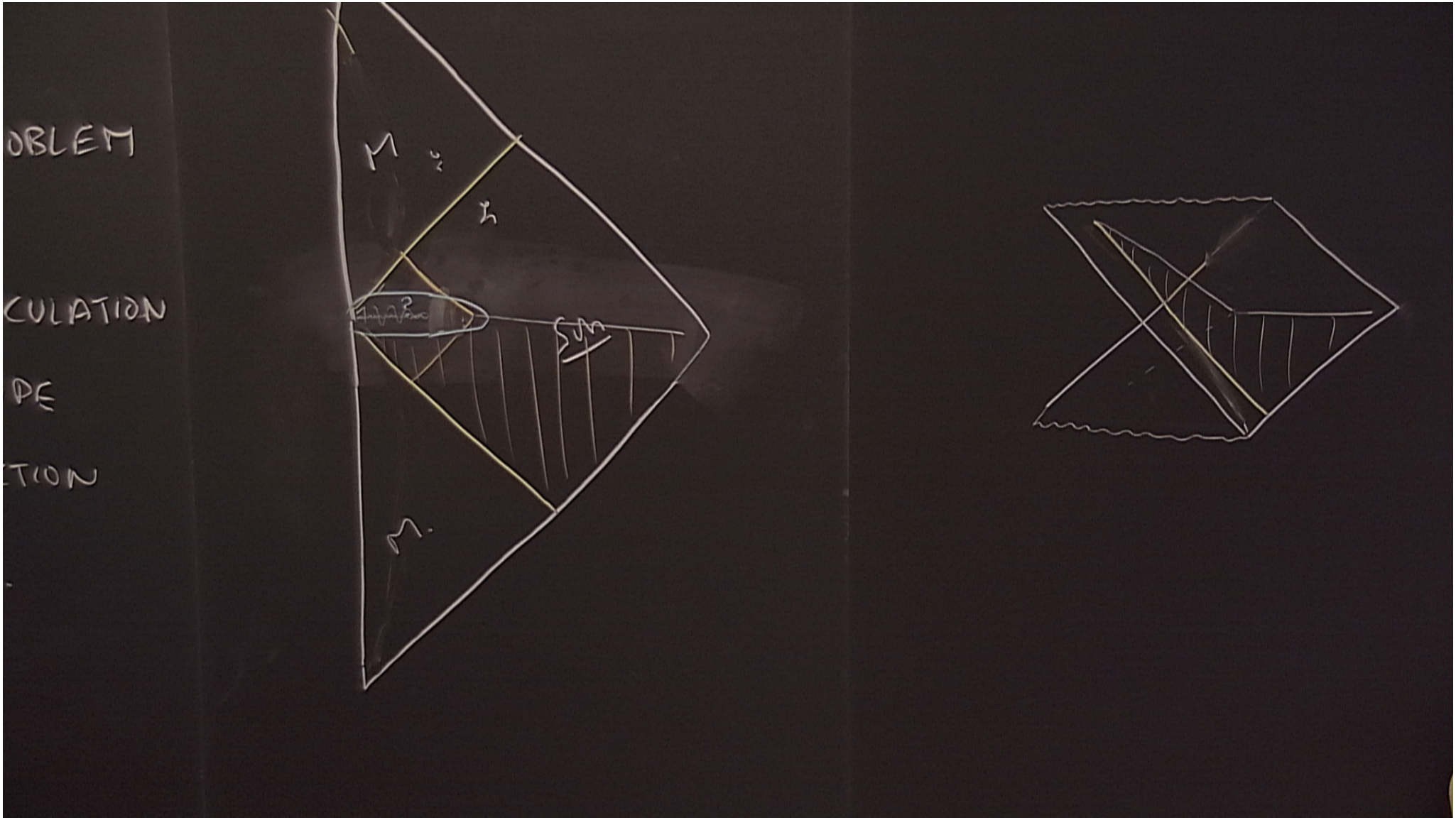




1) Theorem $W_e(h) < \infty$

2) $\forall$ $A_v \sim e^{is S_{Regge}}$


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$W = \lim_{e \to \infty}$

$$W_e(h_e) = \int_{SU(2)} dh_{v_e f} \delta(h_e) \prod_v A_v(h_e)$$

$$A_v(h_e) = \int_{SU(2)} dg_{v_e} \prod_f \sum_j (2j+1) D^j_{mn}(h_e) D^{j,j}_{jm\,jn}(g_e \triangleright g_e)$$

1) Theorem $\pm$ $W_e(h)$

2) $\cdot \geq A_v \sim e^{is}$

II

- class: BH states
- QFT on curv ST. Hawking-
- Q.G. Tunneling-

III

MODEL

- BH spherically symm. (unexcited)
- thin null shell (")
- disregard dissipation (")
- $\hookrightarrow$ T-invariant
- dominated by it "Large d.o.f."

$$ds^2 = -F(u,v)\,du\,dv + r^2(uv)\,d\Omega^2$$

$u_1 v_1$

$u_s v_s$

$$F(uv) = \frac{32m^2}{r} e^{-\frac{r}{2m}}$$

$$\left(1 - \frac{r}{2m}\right) e^{\frac{r}{2m}} = uv$$

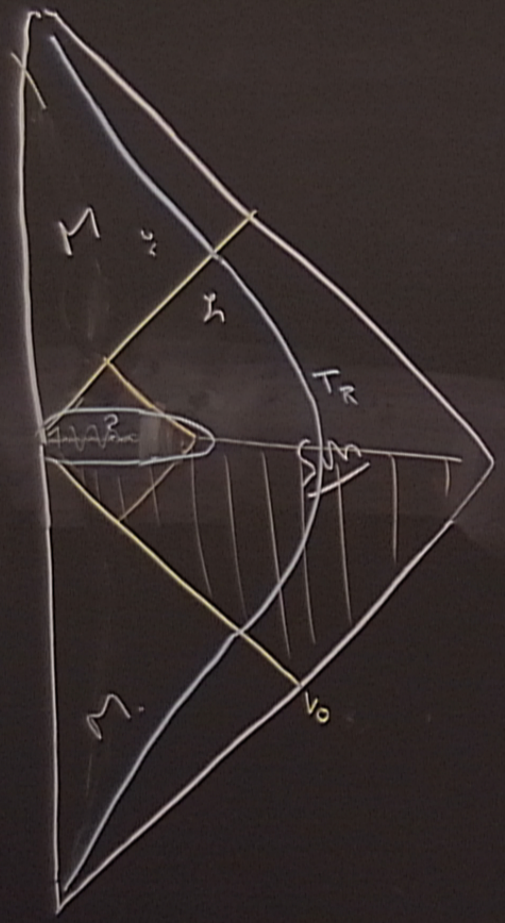
PROBLEM

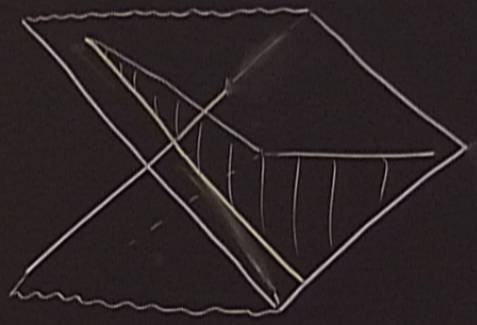
CALCULATION

LITUPE

EDICTION

ICS.





$$A_v(h_e) = \int_{SU(2)} dg_{ve} \prod_f \sum_j (2j+1) D^j_{mn}(h_e) D^{j,j}_{jm\,jn}(g_e \vec{B}_e)$$

$$\left| \cdot \right|^2 \;\; 1 \cdot \; 2 \; A_v \sim e^{\text{Regge}}$$

II

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- QFT on curv ST: Hawki-
- QG-Tunnellig-

III

MODEL

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- thin null shell (")
- disregard dissipation (")
- ↳ T-invariant
- dominated by it "Large d.o.f"

$$ds^2 = -F(u,v)\,du\,dv + r^2(uv)\,d\Omega^2$$

$u_M v_M$

u_s s

$$F(uv) = \frac{32m^2}{r} e^{-\frac{r}{2m}}$$

$$\left(1 - \frac{r}{2m}\right) e^{\frac{r}{2m}} = uv$$

Horizon

$V_p = V_0$

$V_M = 0$

$$u_s(u_M) = \frac{1}{V_0}\left(1 - \frac{u_M}{4m}\right) e^{\frac{u_M}{4m}}$$

THEORY

YSICAL PROBLEM

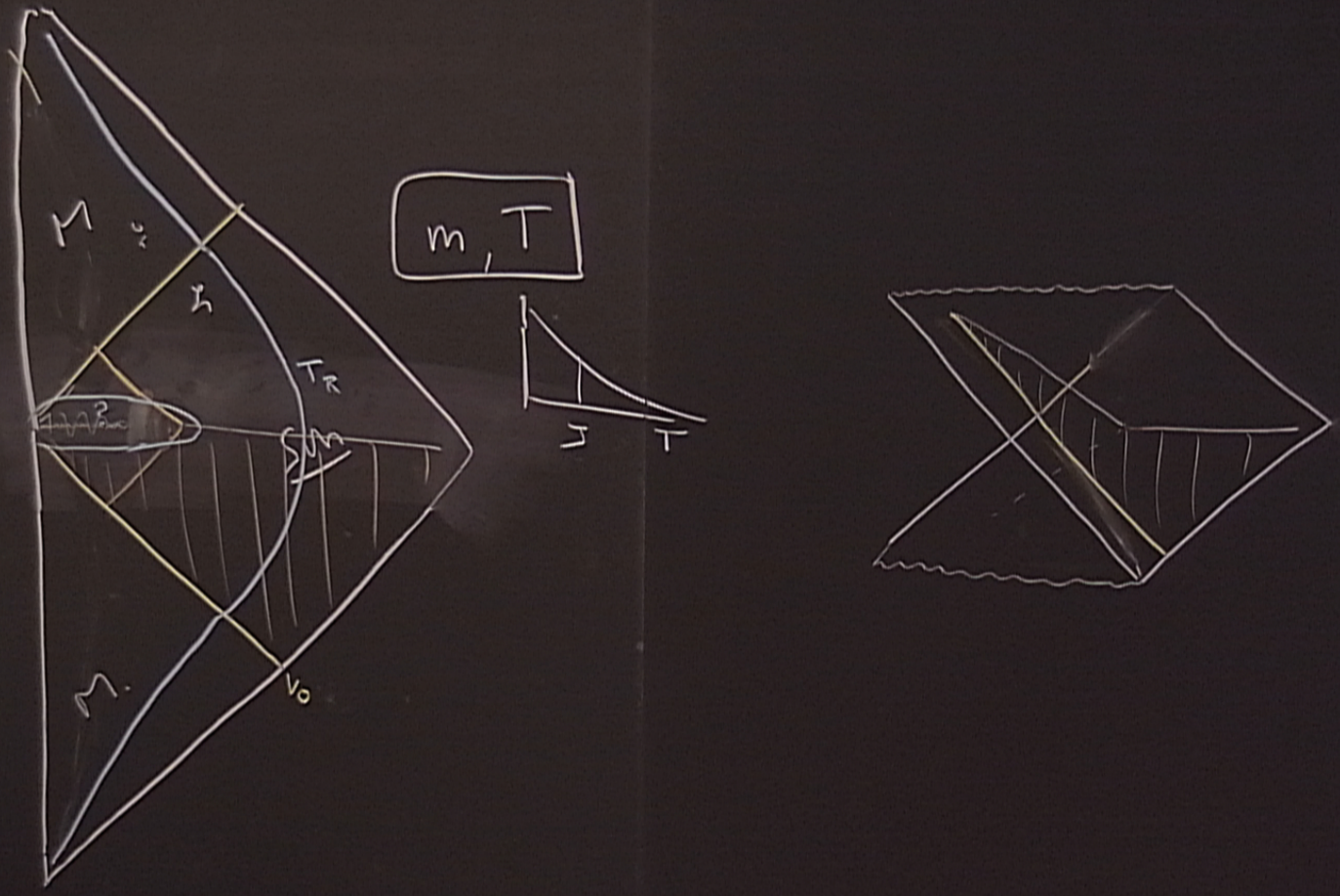
ODEL

G-UP THE CALCULATION

UM AMPLITUDE

NG ⇒ PREDICTION

TOPHYSICS.

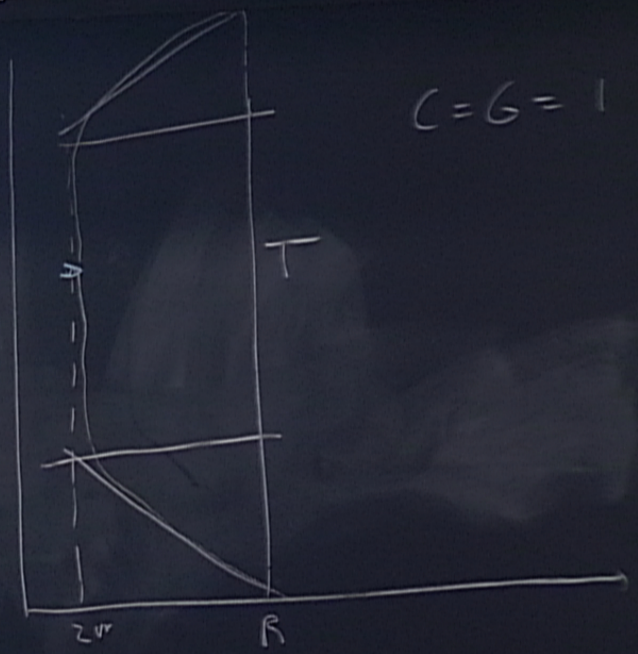


$$T_R = \sqrt{1-\frac{2m}{R}}\left(2R - 8m\,e_m v_0 - 4m\,e_m\left(\frac{R-2m}{2m}-1\right)\right)$$

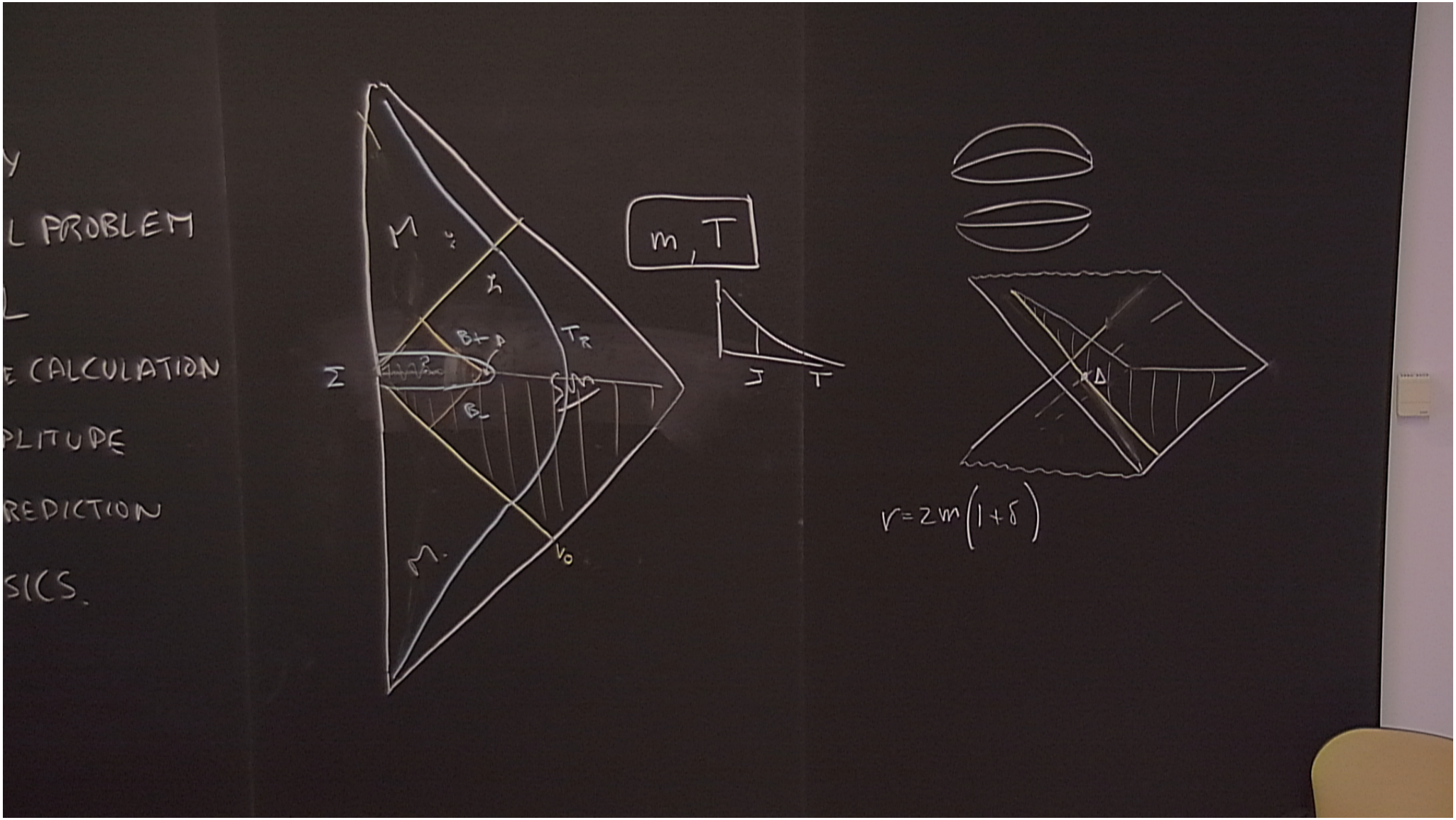
$R \gg 2m$ $\quad T$ = bounce time.

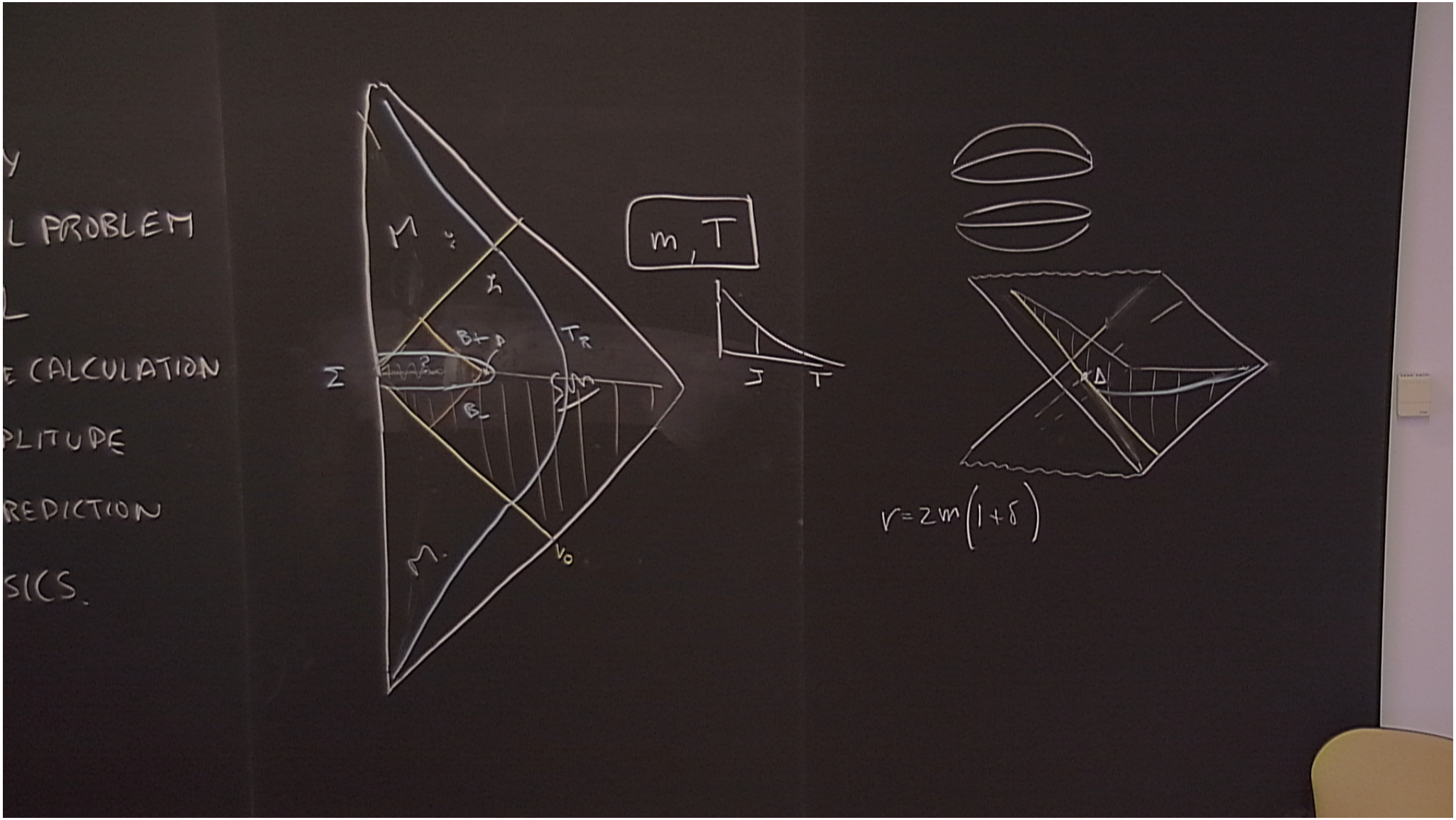
$$= 2R - \overbrace{8m\,e_m v_0}$$

$$T = \lim_{R\to\infty}\left(T_R - 2R\right)$$



$C = G = 1$


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T_R
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SM
B_L
M.
V_0
m, T
J
T
r = 2m(1+δ)


Y
L PROBLEM
L
E CALCULATION
PLITUDE
REDICTION
SICS.
M
m, T
J
T
r = 2m(1+δ)

$$\left(1-\frac{r}{2m}\right)e^{\frac{r}{2m}} = -v_0^2$$

$$-\delta(1+\delta) = -v_0^2$$

$$\delta = v_0^2$$

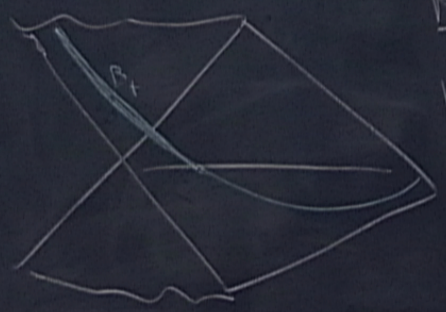
$$\boxed{T = -8m \ln v_0 = -4m \ln \delta}$$

Lemaître time

$$t = t_s + 2\sqrt{2mr_s} + 2m \ln\left|\frac{\sqrt{r_s/2m}-1}{\sqrt{r_s/2m}+1}\right|$$

$$r \qquad r_s^3 = \frac{9m}{2}(r-t)$$

$$ds^2 = -dt^2 + \frac{2m}{r_s}dr^2 + r_s^2 d\Omega^2$$



B_+ is flat

$K_{ab}dx^a dx^b =$

$$\left(1-\frac{r}{2m}\right)e^{\frac{r}{2m}} = -v_0^2$$

$$-\delta(1+\delta) = -v_0^2$$

$$\delta = v_0^2$$

$$\boxed{T = -8m \ln v_0 = -4m \ln \delta}$$

Lemaître time

$$t = t_s + 2\sqrt{2mr_s} + 2m \ln\left|\frac{\sqrt{r_s/2m}-1}{\sqrt{r_s/2m}+1}\right|$$

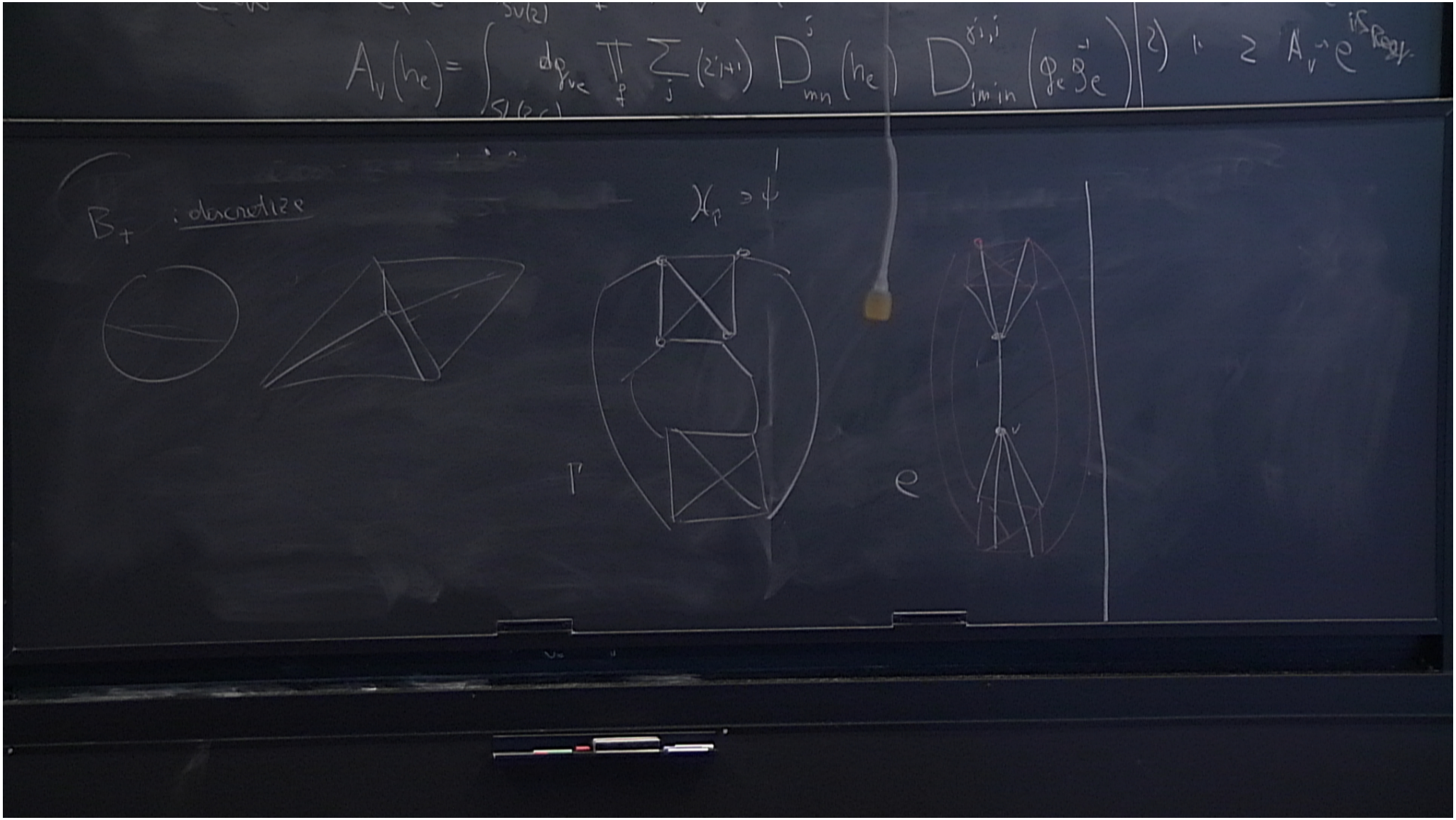
$$r \cdot r_s^3 = \frac{9m}{2}(r-t)$$

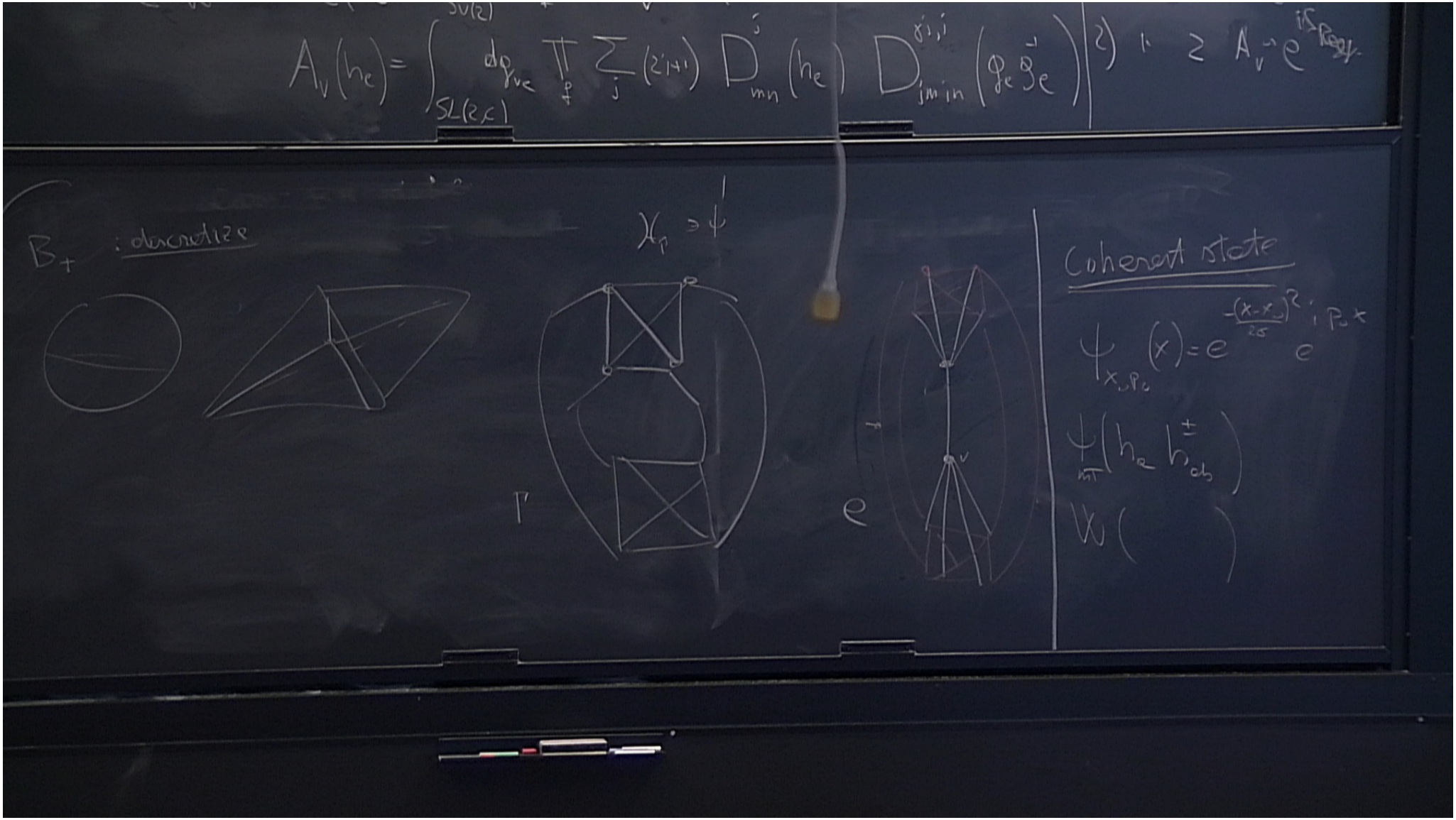
$$ds^2 = -dt^2 + \frac{2m}{r_s}dr^2 + r_s^2 d\Omega^2$$

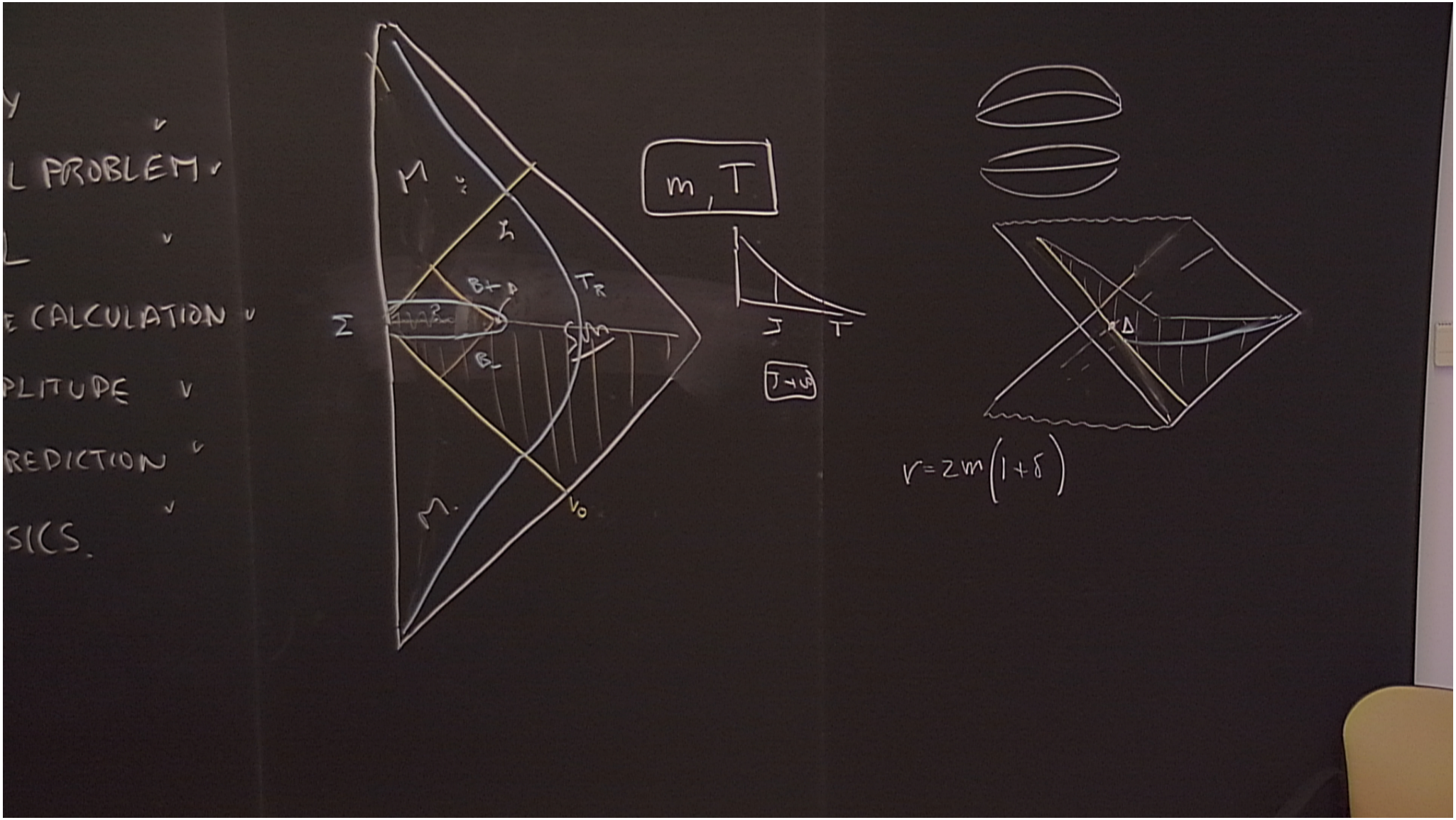


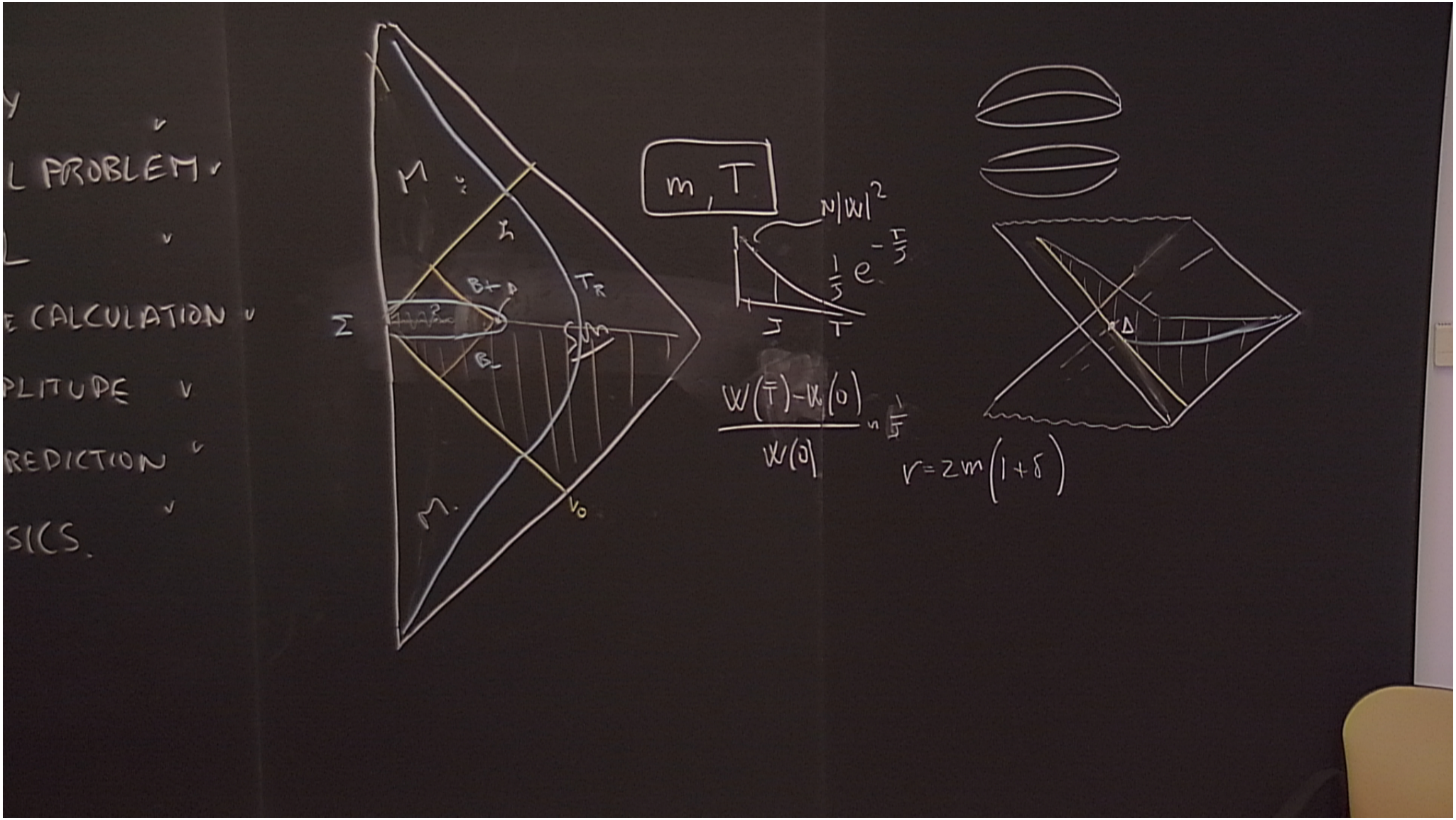
B_+ is flat

$$V_d\, dx^a dx^b = (2m)^{3/2} r_s^{-5/2}\, dr^2 - \sqrt{2mr_s}\, d\Omega^2$$


$A_v(h_e) = \int_{SU(2)^{|E|}} dg_{v e} \prod_f \sum_j (2j+1) D^j_{mn}(h_e) D^{\gamma j, j}_{jm\,in}(g_e \triangleright \vec{z}_e)$
B_+ : discretize
$\chi_p = \psi$
Γ
e

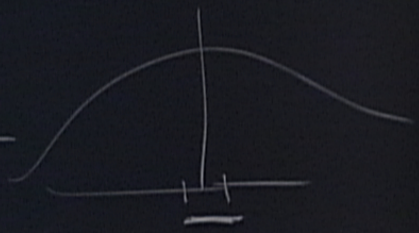

$A_v(h_e) = \int_{SL(2,C)} dg_{ve} \prod_f \sum_j (2j+1) D^j_{mn}(h_e) D^{\gamma j, j}_{jm\,in}(g_e \triangleright \vec{z}_e)$
B_+ : discretize
$\chi_n \Rightarrow \psi$
Coherent state
$\psi_{x,p}(x) = e^{-\frac{(x-x_0)^2}{2\sigma}} e^{ip_0 x}$
$\psi_{\pm}(h_e, h^{\pm}_{ob})$
$W(\quad)$


L PROBLEM
E CALCULATION
PLITUDE
REDICTION
SICS
M
Σ
M.
B_+
B_-
T_R
V_0
m, T
T
$r = 2m(1+\delta)$
Δ


L PROBLEM
CALCULATION
PLITUDE
REDICTION
SICS.
Σ
M
M.
B_+
B_-
T_R
V_0
m, T
$N|W|^2$
$\frac{1}{5}e^{-\frac{T}{5}}$
$\frac{W(\bar{T})-W(0)}{W(0)}$
$r = 2m(1+\delta)$
Δ

$$W(m,T) = \int_{SU(2)} \int_{SL(2C)} \sum_j \cdots\cdots$$

$j_0 \sim 2m$



$$= \sum_j \underbrace{f(j)}_{\text{varying with } j} e^{i\frac{T}{4m}j} \; e^{-\frac{(j-j_0)^2}{\sigma}}$$

$J \sim m^2$

① Bnet $\sum_j \to j = j_0$

$$= e^{i\frac{T}{4m}j} \left(1 + e^{\frac{i}{2}\frac{T}{4m}} + e^{-\frac{i}{2}\frac{T}{4m}}\right) \sim A + B\frac{T^2}{m^2}$$

$\Gamma \propto m^2$

$\Gamma \propto \sqrt{\frac{G^3}{\hbar c^2}}\, m^2$

BH. Reflective

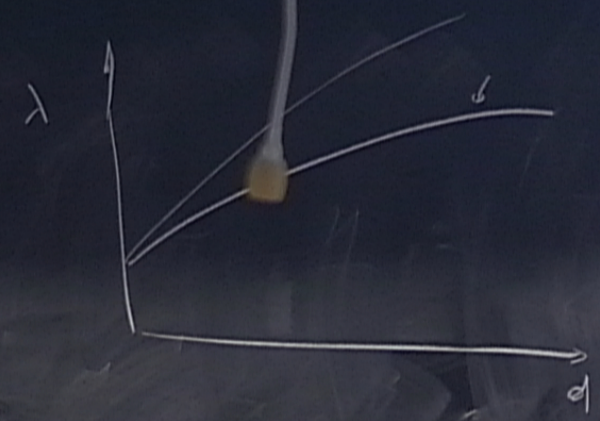
$\Gamma = T_{HUBBLE}$

$m = 10^{23}\ Kg = 0.1\ M_\oplus$

$r_{sch} = 0.1\ cm$ (FRB)

"production"

$\lambda_{emitted} \sim 0.1\ cm$



FRB

(high energy γ-rays)