Title: Effective Field Theory of Echoes

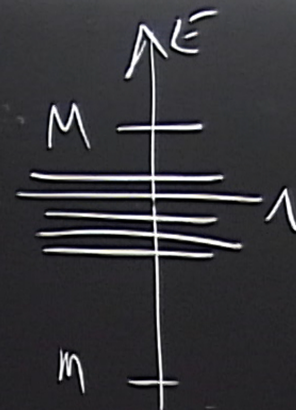
Speakers: Cliff Burgess

Collection: Echoes in Southern Ontario

Date: February 25, 2020 - 9:00 AM

URL: http://pirsa.org/20020091

1804.10324
1808.00847

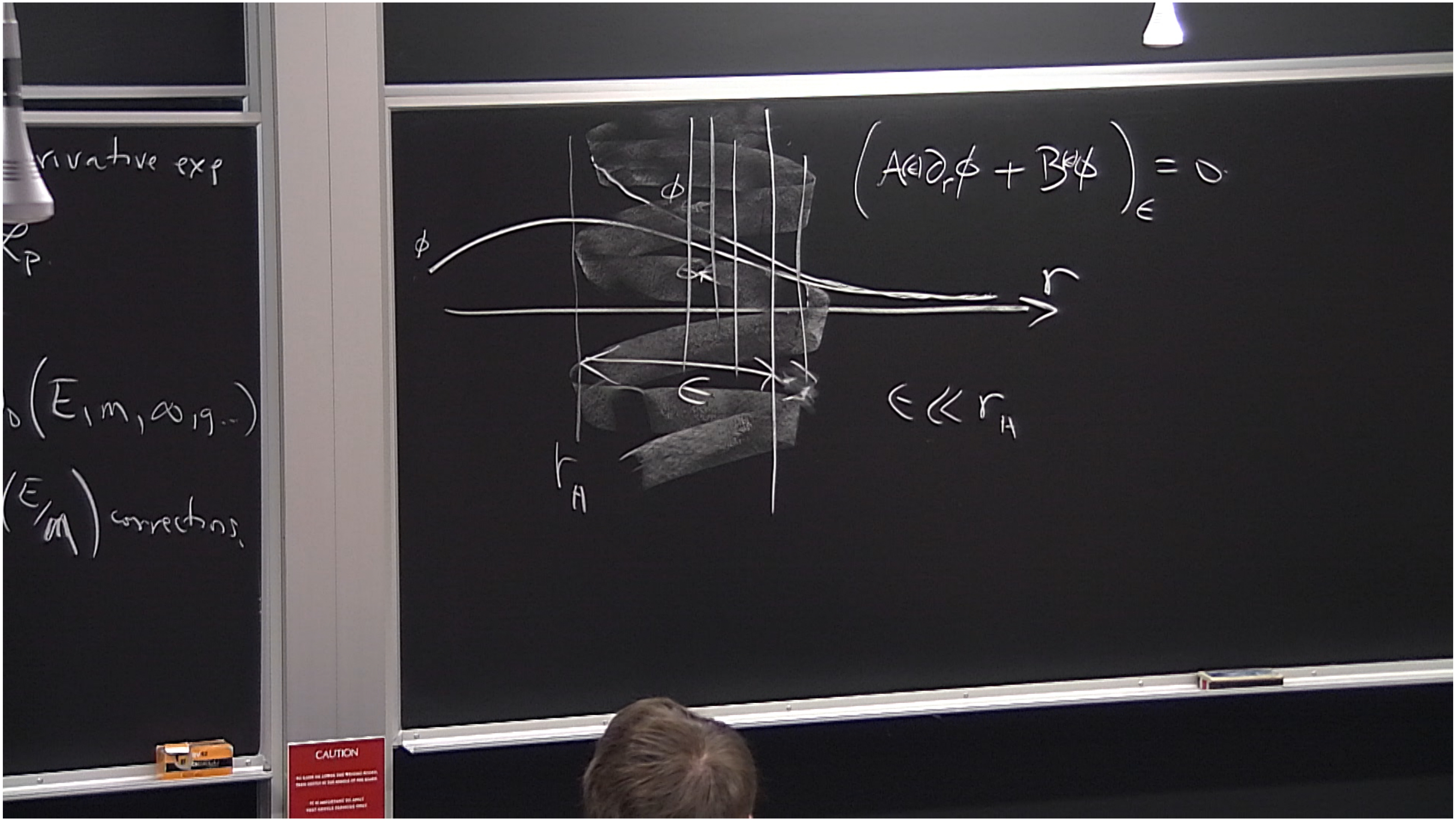


erivative exp

$$\mathcal{L} = \mathcal{L}_{LO} + \sum_{p}^{\infty} \frac{g_p}{M^{n_p}} \mathcal{L}_p$$

$$O(E, m, M, g \ldots) \simeq O_0(E, m, \infty, g \ldots)$$

$+ \left(E/m\right)$ corrections.

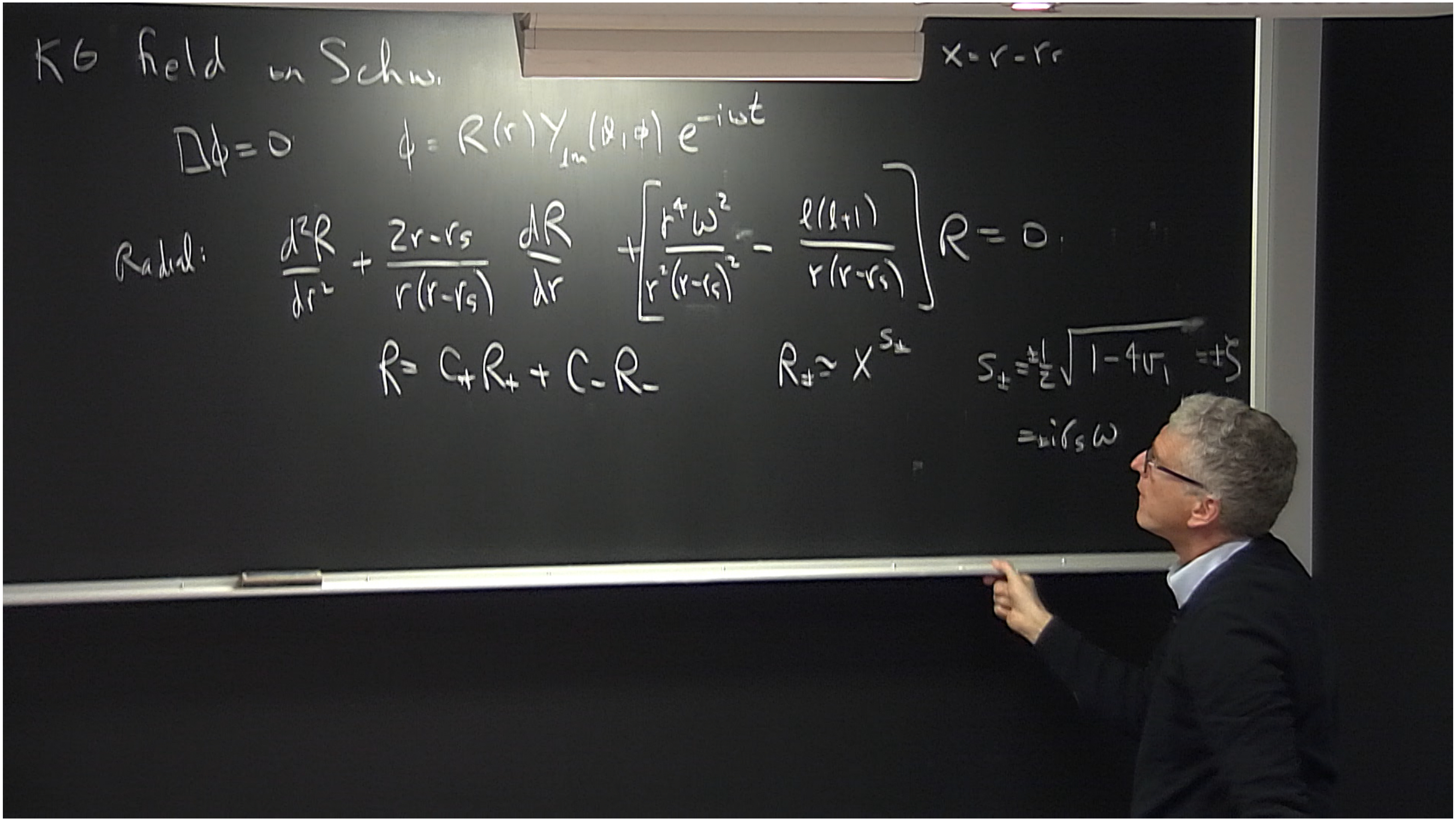

rivative exp
$\left(A(\epsilon)\partial_r \phi + B(\epsilon)\phi \right)_\epsilon = 0$
ϕ
r
ϵ
$\epsilon \ll r_H$
r_H
$(E, m, \omega, g \ldots)$
(E/m) corrections
CAUTION

Radial: $\frac{d^2R}{dr^2} + \frac{2r-r_s}{r(r-r_s)} \frac{d}{dr} \ldots \Big] R = 0.$

$$R = C_+R_+ + C_-R_- \qquad R_\pm \simeq x^{s_\pm} \qquad s_\pm = \pm\frac{1}{2}\sqrt{1-4v_1} = \pm\zeta$$

$$= \pm i r_s \omega$$

$$v_1 = \frac{1}{4} + r_s^2\omega^2$$


KG field in Schw.
x = r - rs
□φ = 0
φ = R(r) Y_lm(θ, φ) e^{-iωt}
Radial:
d²R/dr² + (2r - rs)/(r(r - rs)) dR/dr + [r⁴ω²/(r²(r - rs)²) - l(l+1)/(r(r - rs))] R = 0
R = C+ R+ + C- R-
R± ≃ x^{s±}
s± = ±½ √(1 - 4v₁) = ±ζ
= ±i rs ω

$= \pm i r_s \omega$

GR perfectly infalling b.c. at $r = r_H$

$x = r - r_H$

$r_s = r_H = 2GM$

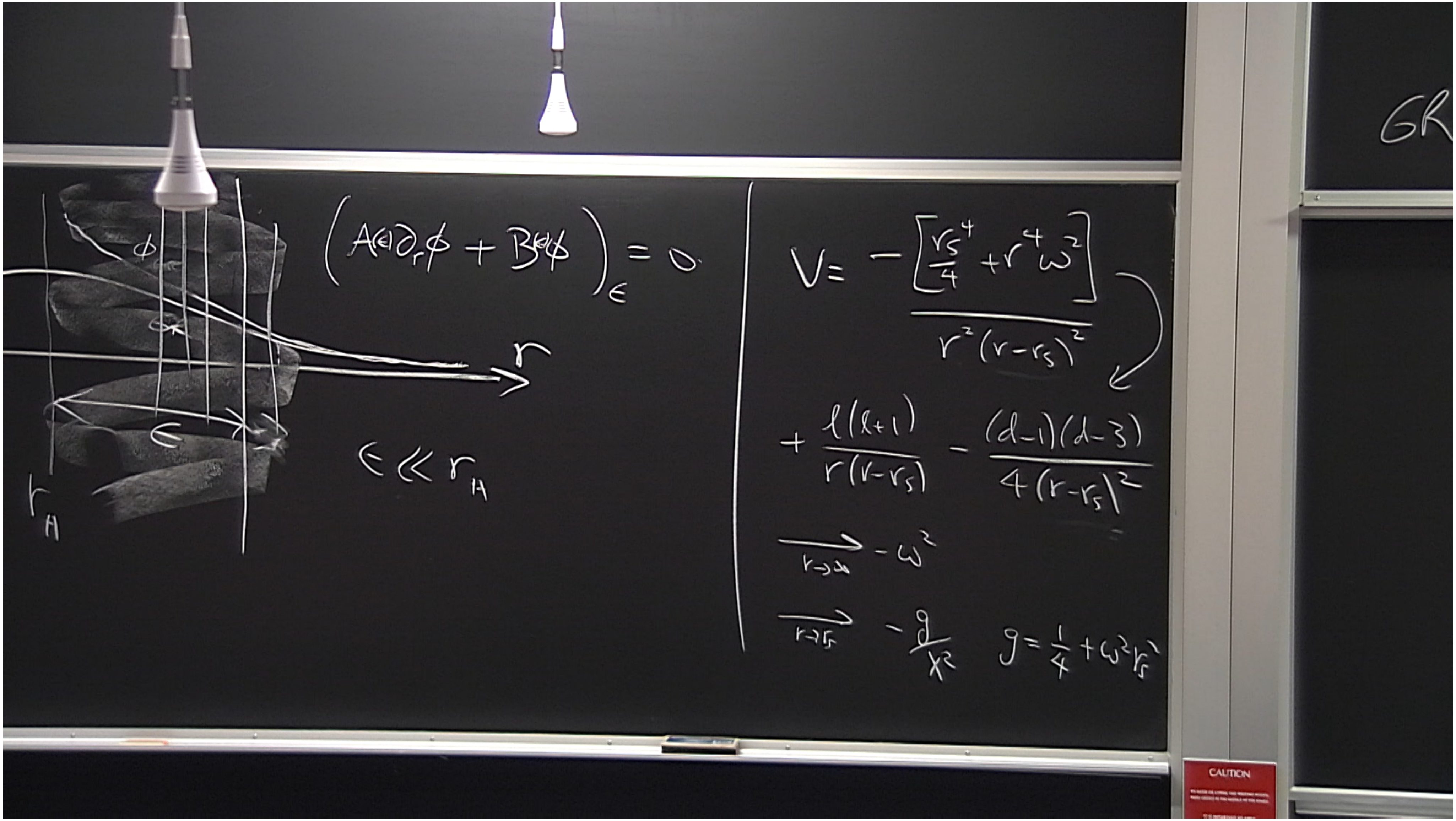
$V_1 = \frac{1}{4} + r_s^2 \omega^2$

$R = F_d(r) \chi_d(r)$

Choose F s.t. χ eq^n looks like $\boxed{-\nabla^2 \chi + V(r) \chi = 0.}$

$$\frac{d^2\chi}{dx^2} + \frac{(d-1)}{x} \frac{d\chi}{dx}$$

sol^n: $F_d = C_F \frac{(r-r_s)^{(d-1)/2}}{\sqrt{r(r-r_s)}}$


$\left(A(\epsilon)\partial_r\phi + B(\epsilon)\phi\right)_\epsilon = 0$
ϕ
r
ϵ
r_H
$\epsilon \ll r_H$
$V = -\frac{\left[\frac{r_s^4}{4} + r^4\omega^2\right]}{r^2(r-r_s)^2} + \frac{l(l+1)}{r(r-r_s)} - \frac{(d-1)(d-3)}{4(r-r_s)^2}$
$\xrightarrow[r\to\infty]{} -\omega^2$
$\xrightarrow[r\to r_s]{} -\frac{g}{x^2}$
$g = \frac{1}{4} + \omega^2 r_s^2$
GR
CAUTION

at $r = r_H$ $\qquad$ $x = r - r_H$

$r_s = r_H = 2GM$

$v_1 = \frac{1}{4} + r_s^2 \omega^2$

$\to r \quad R = F_d(r)\,\chi_d(r)$

Choose F s.t. χ eq^n/

looks like $\boxed{-\nabla^2 \chi + V(r)\,\chi = 0.}$

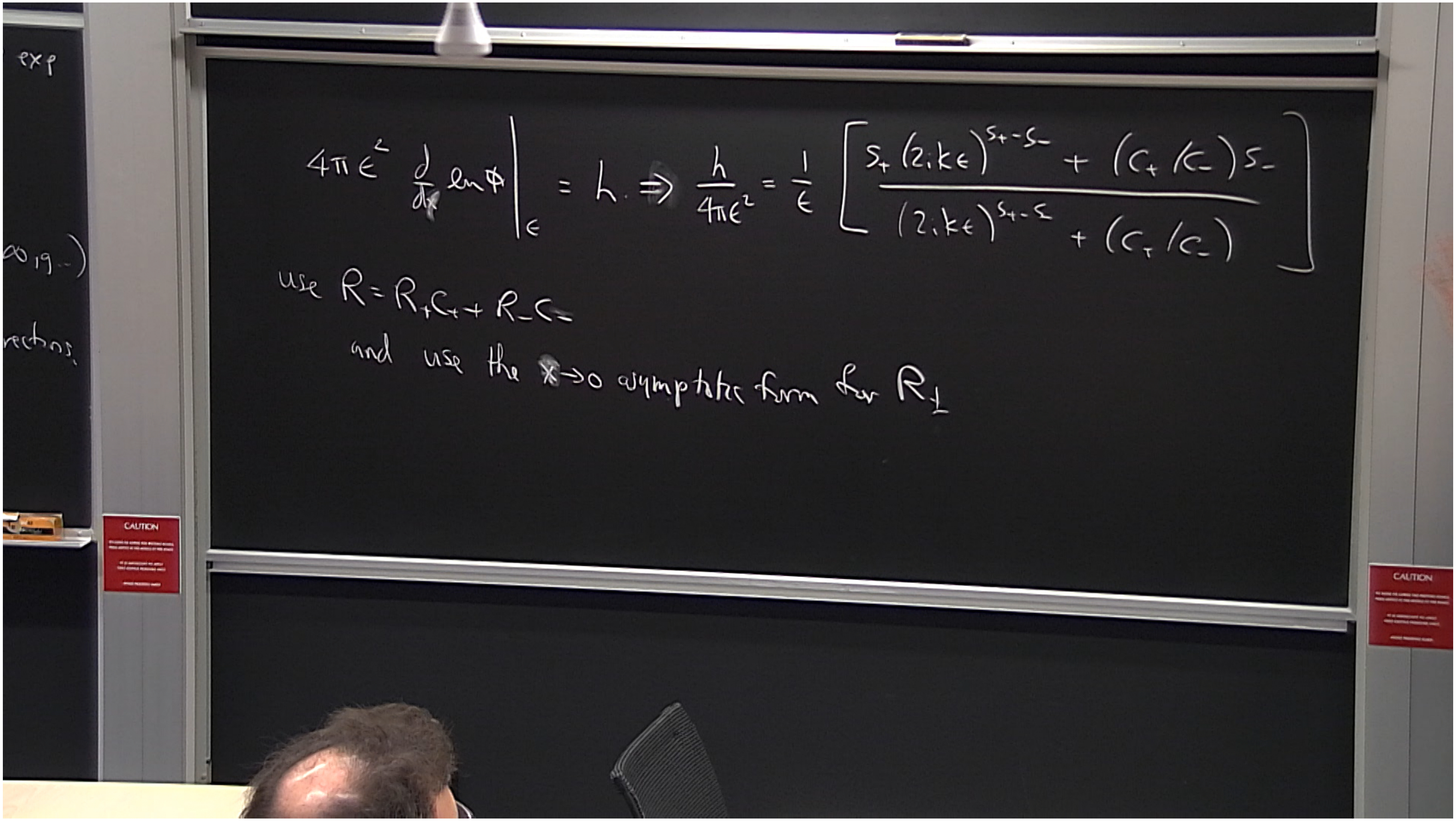
$$\frac{d^2\chi}{dx^2} + \frac{(d-1)}{x}\frac{d\chi}{dx}$$

sol^n: $F_d = C_F \frac{(r-r_s)^{(d-1)/2}}{\sqrt{r(r-r_s)}}$

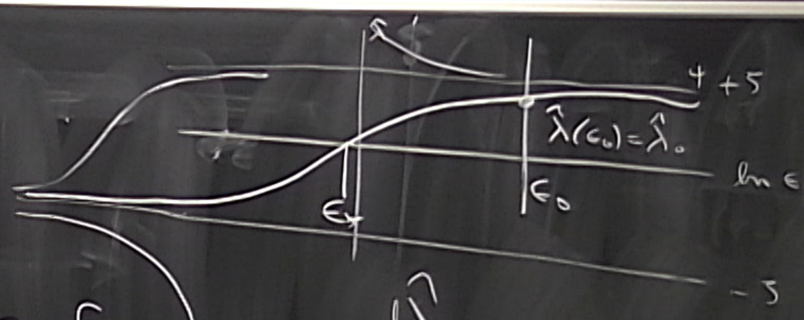
Claim: if you know the action of the source at $r=0$

$$S = \int \overset{q\,A_0}{d\tau\,\mathcal{L}}(\phi(r)) = \int d^4x\, \overbrace{\mathcal{L}(\phi)}^{h\phi^2}\, \delta^3(x)$$

3D $$\left(4\pi r^2 \frac{\partial\phi}{\partial r}\right)\Big|_{r=\epsilon} = \left(\frac{\partial\mathcal{L}}{\partial\phi}\right)\Big|_{r=\epsilon} = h^{(\epsilon)}\phi\Big|_{\epsilon}$$


$4\pi\epsilon^2 \frac{d}{dx}\ln\Phi\Big|_\epsilon = h \Rightarrow \frac{h}{4\pi\epsilon^2} = \frac{1}{\epsilon}\left[\frac{s_+(2ik\epsilon)^{s_+-s_-} + (C_+/C_-)s_-}{(2ik\epsilon)^{s_+-s_-} + (C_+/C_-)}\right]$
use $R = R_+C_+ + R_-C_-$
and use the $x\to 0$ asymptotic form for $R_\pm$

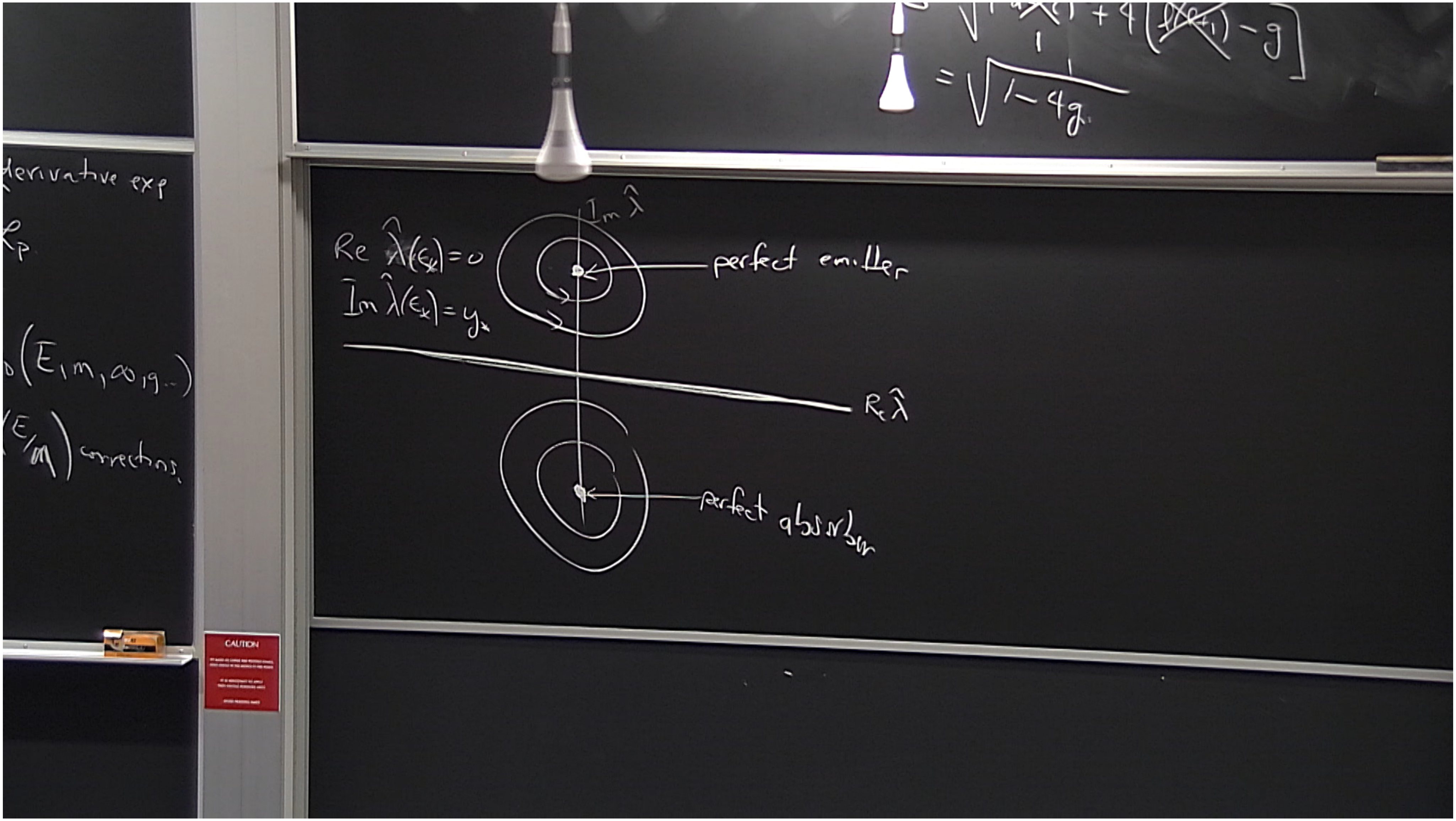
$$\frac{h}{4\pi\epsilon^2} = \frac{1}{2\epsilon}\left[-1+\hat{\lambda}\right]$$



varying ϵ with C_+/C_- fixed $\longrightarrow$ $\epsilon\dfrac{d\hat{\lambda}}{d\epsilon} = \dfrac{1}{2}\left(\zeta^2-\hat{\lambda}^2\right)$

$$\zeta = \sqrt{(\underbrace{\cancel{d-2}}_{1})^2 + 4\left[\cancel{\ell(\ell+1)} - g\right]}$$

$$= \sqrt{1-4g}$$


derivative exp
Re λ̂(ε*) = 0
Im λ̂(ε*) = y*
Im λ̂
perfect emitter
Re λ̂
perfect absorber
corrections
= √(1 − 4g)