

# Mostly live-streamed teaching with a visualiser

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TALMO, More tips for tackling 2021



### Why synchronous?

- opportunities for interactive learning
- mental health benefits: normality, routine, contact during lockdown
- few disadvantages for students who prefer asynchronous teaching

### Units taught

- half of Applied Partial Differential Equations 2 (2nd year, TB2, 141 students)
- Quantum Chaos (4th year, TB1, 30 students)
- Advanced Quantum Theory (4th year, TB2, 13 students)

live audience: about half (less with 9am slots)

# Technology

b) Inhomogeneous boundary conditions

$u_t = Du_{xx}$   
 $u(0,t) = g(t), u(a,t) = h(t)$   
 $u(x,0) = \varphi(x)$

Idea:  $u(x,t) = v(x,t) + w(x,t)$

Satisfies BC      Satisfies BC      Vanishes at boundary


e.g. choose:  
 $v(x,t) = g(t) + \frac{h(t)-g(t)}{a}x$   
(for  $g, h$  constant:  $v_t = 0, v_{xx} = 0$ )  
( $\Rightarrow$  this is particular solution)

Then  $w(x,t)$  satisfies

BC:  $w(0,t) = 0$   
 $w(a,t) = 0$

PDE:  $w_t = u_t - v_t$   
 $= Du_{xx} - v_t$   
 $= Dv_{xx} + Dw_{xx} - v_t$   
 $w_t = Dw_{xx} - v_t$

IC:  $w(x,0) = u(x,0) - v(x,0)$   
 $w(x,0) = \varphi(x) - v(x,0)$



- Zoom
- visualiser with 2 sheets
- option I: share screen > advanced > content from 2nd camera
- option II: merge with camera in OBS, export as virtual camera

OBS 26.0.2 (64-bit, windows) - Profile: Untitled - Scenes: Untitled

File Edit View Profile Scene Collection Tools Help

5 Path integrals in second quantisation

5.1 Bosons

consider trace, first in single particle QM

$$\text{tr} e^{-\frac{i}{\hbar} H t} = \int d^N r \langle r | e^{-\frac{i}{\hbar} H t} | r \rangle$$

$k(r, \xi, t)$

Motivation:

- Stat Mech:  $\text{tr} e^{-\beta \hat{H}}$  accessible by  $\frac{i}{\hbar} t \rightarrow \beta$
- Quantum chaos: density of states  $\sum \delta(E - E_j)$  accessible from prop. by Laplace transf. + trace

Hamiltonian mechanics path integral

$$\langle r_f | e^{-\frac{i}{\hbar} H t} | r_0 \rangle$$

$\downarrow \downarrow \downarrow \downarrow \downarrow$

$$= \int D[r] D[p]$$


$$r(0) = r_0 \quad \exp\left(\frac{i}{\hbar} \int_0^t [p(t) \cdot \dot{r}(t) - H(r(t), p(t))] dt\right)$$

$$r(t) = r_f$$

where

$$\int D[r] D[p] \dots$$

$$= \lim_{N \rightarrow \infty} \frac{1}{(2\pi\hbar)^{nN}} \int d^n r_1 \dots d^n r_{N-1} d^n p_0 \dots d^n p_{N-1} \dots$$



No source selected

Scenes

Visualizer

Presentation picture 1

triangle

04 flat

11 54

11 54 flat

Browser

+

+

Sources

Audio Input Capture

Video Capture Device 3

Video Capture Device

+

+

Audio Mixer

Audio Input Capture 0.0 dB

Desktop Audio 0.0 dB

Mic/Aux -inf dB

Scene Transitions

Fade

Duration 300 ms

Controls

Start Streaming

Start Recording

Stop Virtual Camera

Studio Mode

Settings

Exit

(M) LIVE: 00:00:00 ● REC: 00:00:00 CPU: 7.3%, 30.00 fps

## Zoom polls

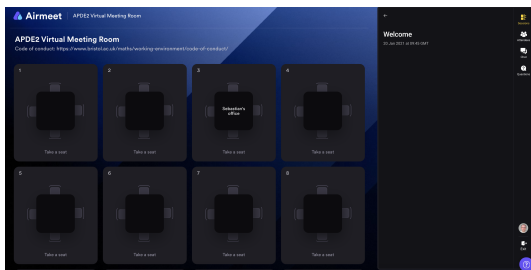
The image shows three screenshots of Zoom poll questions, each in a dark header bar with a title and an 'Edit' button.

- Poll 2: Flux**  
1. What is the flux between sites  $i$  and  $i+1$ ?  
  $p/\tau * (n_i + n_{i+1})$   
  $p/\tau * (n_i - n_{i+1})$   
  $p/\tau * (-n_i + n_{i+1})$   
  $p/\tau * (-n_i - n_{i+1})$
- Poll 6: Separation of variables**  
1. What does  $\lambda$  depend on?  
  $x$  and  $t$   
  $x$   
  $t$   
 none of these
- Poll 19: Equation for Theta**  
1. Do we have to consider  $n=0$ ?  
 yes  
 yes but only the sine term  
 yes but only the cosine term  
 yes but one term has to be replaced  
 no

- questions from students encouraged (during lecture, in the end & after recording)
- open questions to students, verbal or typed answer
  - questions with short answer work better
  - wait for answer

## Interaction

- I asked that some students turn on their camera, but did not insist
- eye contact with camera
- some pre-recorded material to make more space for problems (to different degree in these units, avoid too much back and forth)
- I tried Airmeeet for office hour, this also allows optional group work (which was not taken up)



- Details on [sebastianmueller.weebly.com/teaching.html](https://sebastianmueller.weebly.com/teaching.html)