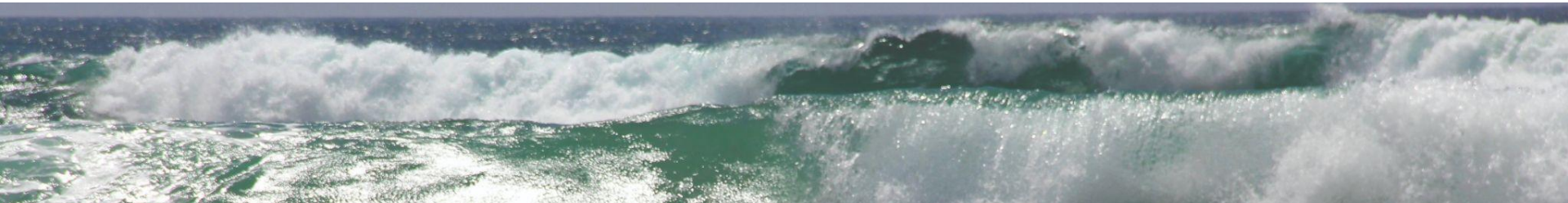
MANCHESTER 1824
The University of Manchester

THE ROYAL SOCIETY

Sound of the Sea

Jack King
University of Manchester



Early observations of wave dynamics in the Hebrides





What I do now… computer simulations of fluids

Lots of coding

```
!! roDY and grad(roDY) used in mixture averaged formulation
roDY = roNdiff(1,lspec)*Y_thlsspec(1)
gradroDY = roVV(1,:) + Y_thlsspec(1)*gradroNdiff(1,:)

!! Augment to include mixture averaged driving forces
roVV(1,:) = roVV(1,:) + roDY*(mxav_store1(1,:) + mxav_store2(1,:)*molar_mass(lspec))

!! Add  gradroDY*(grad(lnT)+grad(lnro)-HgradP/roRT) (NB. transverse terms only)
divroVV = divroVV + dot_product(gradroDY(2:3),mxav_store1(1,2:3)-mxav_store2(1,2:3)*molar_mass(lspec))

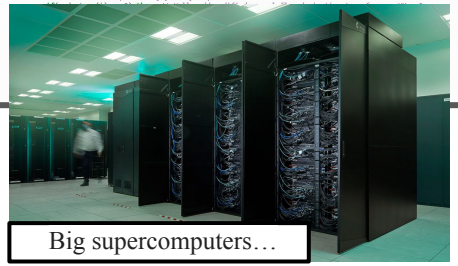
!! Add roDY*(grad(grad(lnT)+grad(lnro)-HgradP/roRT)) (NB. s3 and s4 contain transverse terms only)
divroVV = divroVV + roDY*(mxav_store3(1) + mxav_store4(1)*molar_mass(lspec))

#ifdef soruf
!! Add Dufour terms to dtv.q
!  store_dtff_E(1) = store_dtff_E(1) + Rgas_universal*one_over_molar_mass(lspec)*( &
!                    tdr(1,lspec)*d(roVV**2)(1) &
!                  + T(1)*dot_product(roVV(1,2:3),gradtdr(1,2:3)) &
!                  + tdr(1,lspec)*dot_product(gradT(1,2:3),roVV(1,2:3)) )

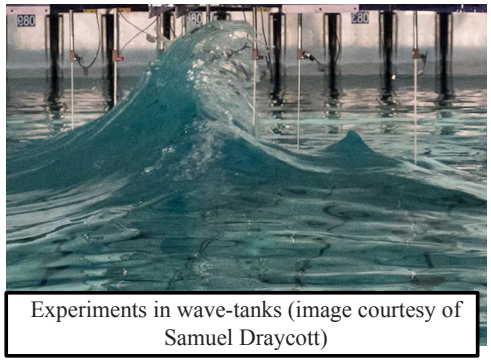
!! Add Soret terms
roVV(1,:) = roVV(1,:) + roDY*tdr(1,lspec)*tmpT*gradT(1,:)
divroVV = divroVV + roDY*tdr(1,lspec)*mxav_store5(1) &
                  + roDY*tmpT*dot_product(gradtdr(1,2:3),gradT(1,2:3)) &
                  + tdr(1,lspec)*tmpT*dot_product(gradT(1,2:3),gradroDY(2:3))
#endif
#endif

!! Up to this point, divroVV only contains transverse terms

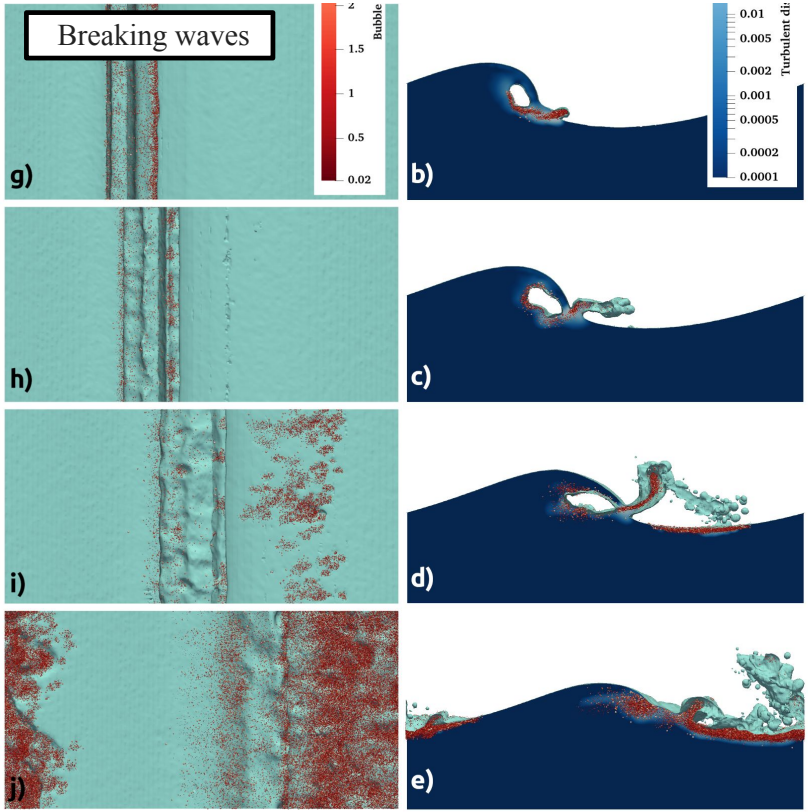
!! zero normal components of flux if required
```

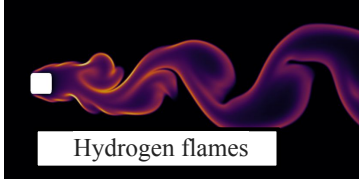


Big supercomputers…



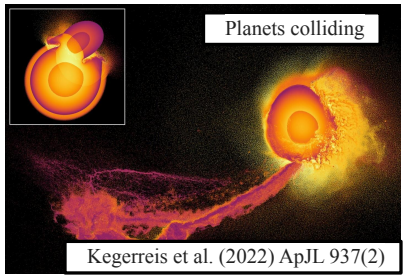
Experiments in wave-tanks (image courtesy of Samuel Draycott)





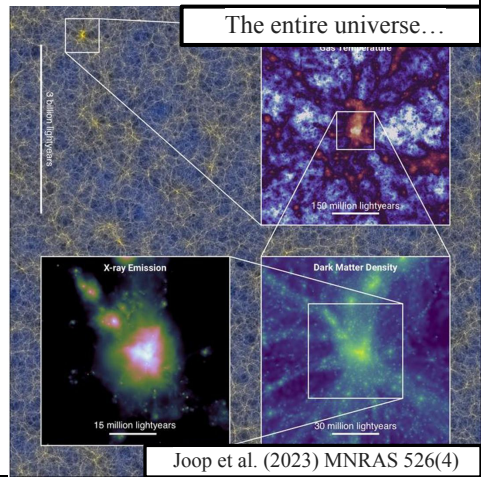
Hydrogen flames

The same techniques are used in lots of areas



Planets colliding

Kegerreis et al. (2022) ApJL 937(2)



Joop et al. (2023) MNRAS 526(4)

Sound of the sea project

$$F = ma$$

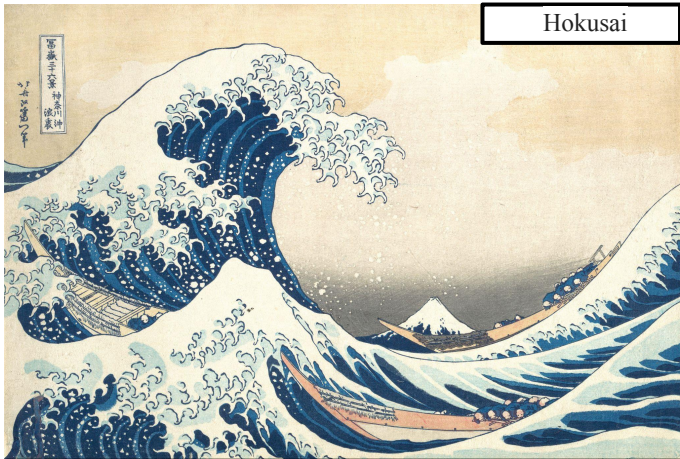
- Fluid mechanics - everywhere! but not taught in schools;
- Waves - accessible and evocative;
- Music - inspired by waves, incorporating waves sounds & scientific data;
- Art - photography, poetry, drawing, painting, printmaking.

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ON THE SEA

It keeps eternal whisperings around
Desolate shores, and with its mighty swell
Gluts twice ten thousand caverns, till the spell
Of Hecate leaves them their old shadowy sound.
Often 'tis in such gentle temper found,
That scarcely will the very smallest shell
Be moved for days from where it sometime fell.
When last the winds of heaven were unbound.
Oh ye! who have your eye-balls vexed and tired,
Feast them upon the wideness of the Sea;
Oh ye! whose ears are dinn'd with uproar rude,
Or fed too much with cloying melody —
Sit ye near some old cavern's mouth, and brood
Until ye start, as if the sea-nymphs quired!

John Keats



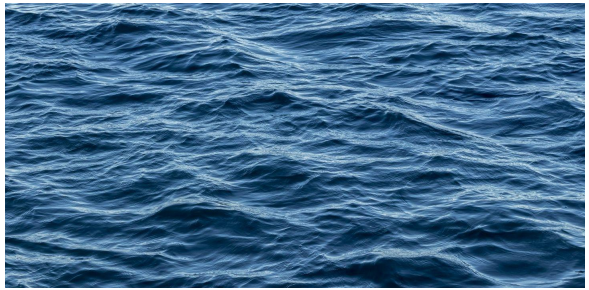
Hokusai

The wind and the waves





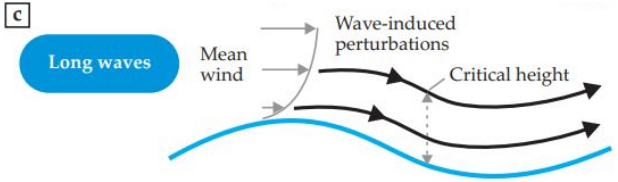
~1cm





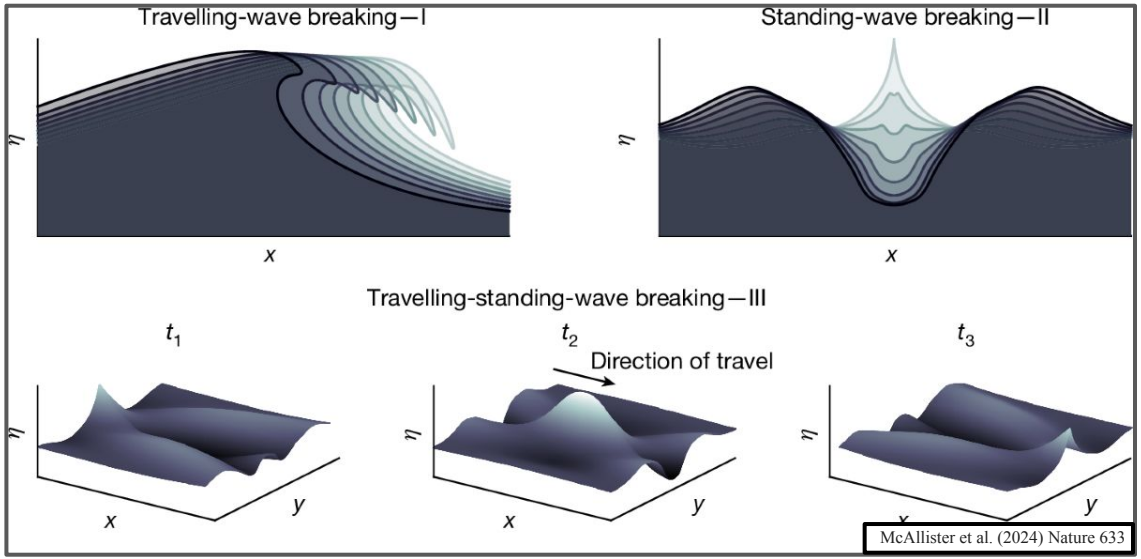
~1m



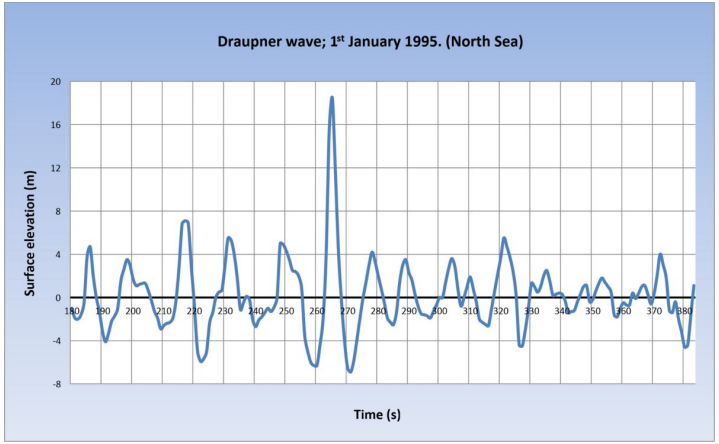


~10m

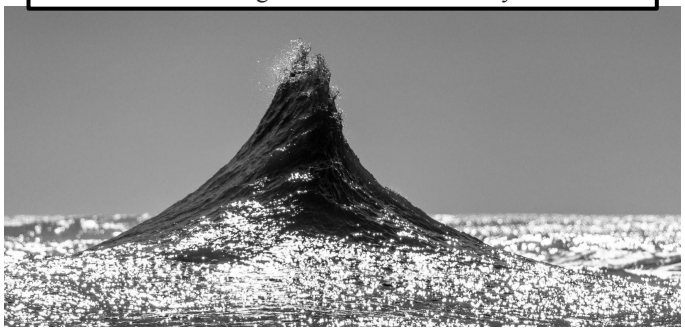
Rogue waves



McAllister et al. (2024) Nature 633

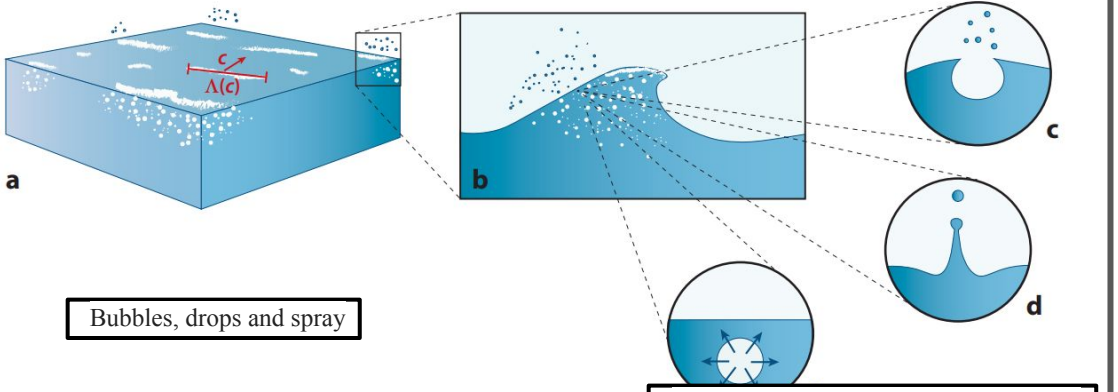


Crossing waves break differently





When waves break…



Bubbles, drops and spray

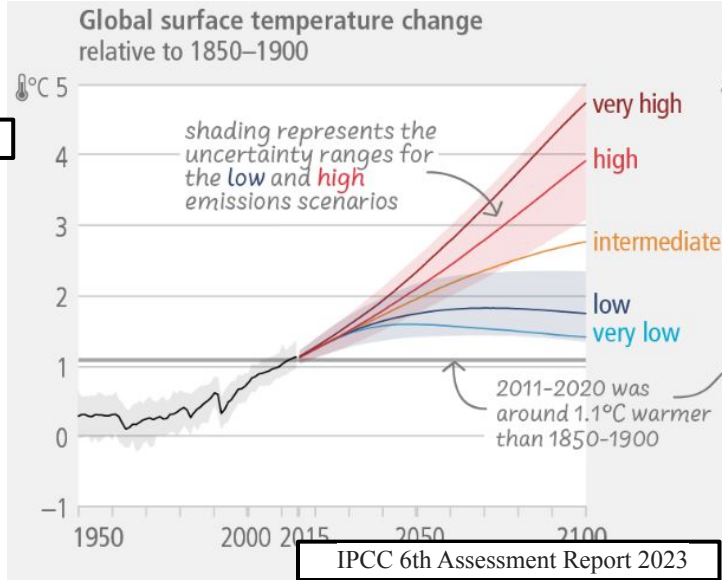
Deike (2022) Annu. Rev. Fluid Mech 54

Deike (2022) Annu. Rev. Fluid Mech 54



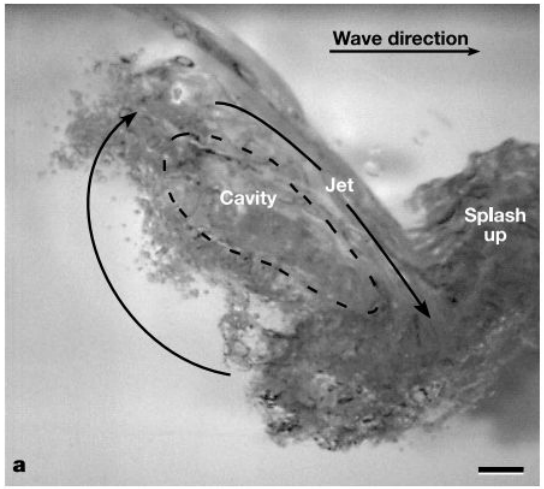
40% of ocean CO2 absorption due to wave breaking

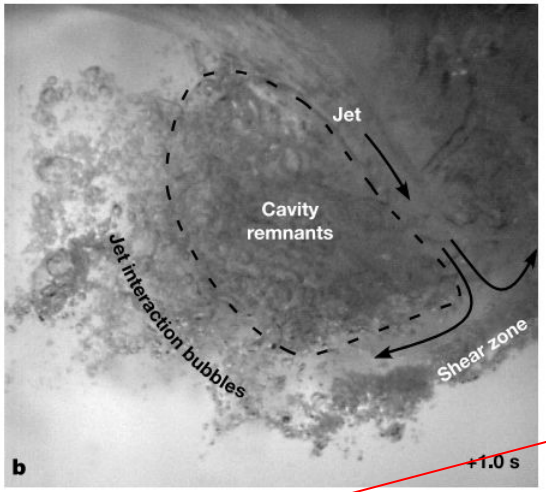


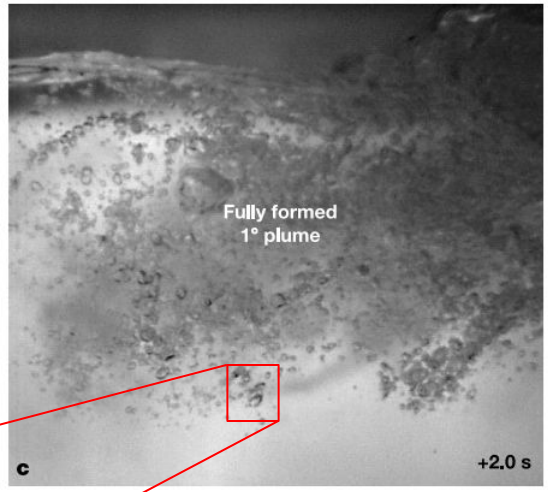


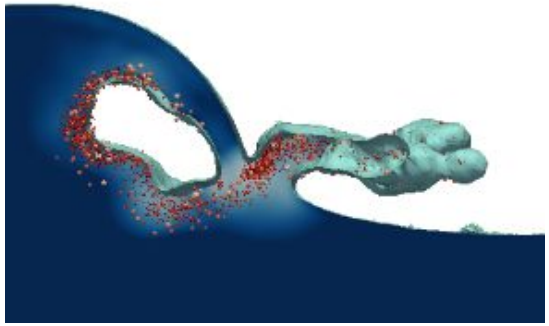
IPCC 6th Assessment Report 2023

Bubbles

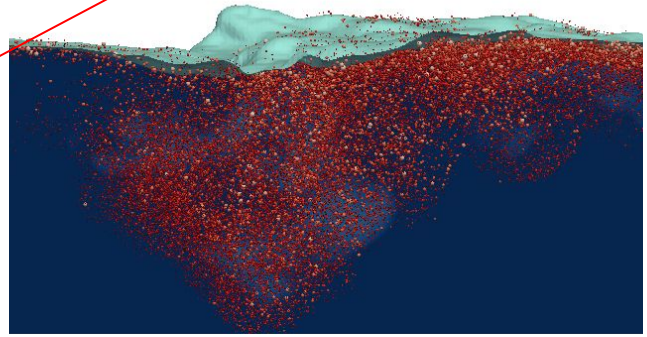












What happens to individual bubbles?

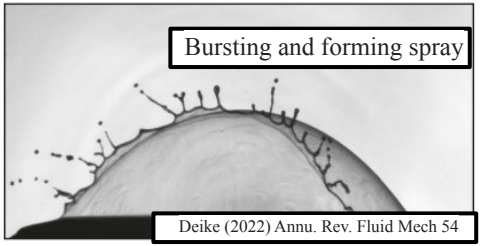
The life of a bubble: turbulence vs. surface tension

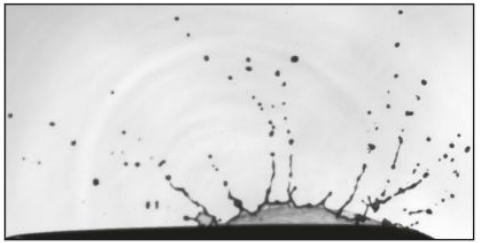
Big whorls have little whorls
Which feed on their velocity,
And little whorls have lesser whorls
And so on to viscosity.

Lewis Fry Richardson, 1922

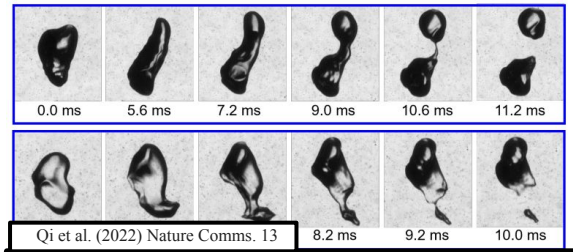
Leonardo da Vinci







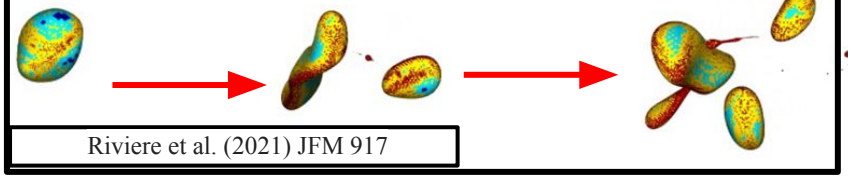
Each droplet can entrain another bubble…



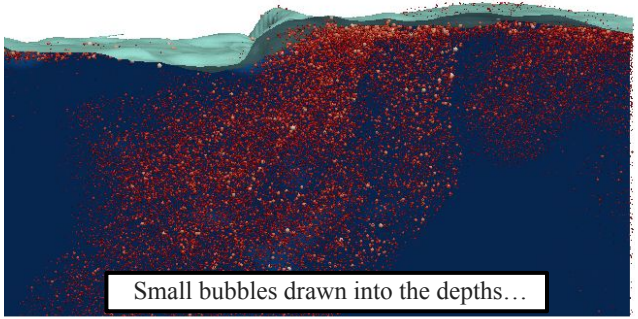
Qi et al. (2022) Nature Comms. 13

Hinze scale ~1mm

Turbulent bubble break-up



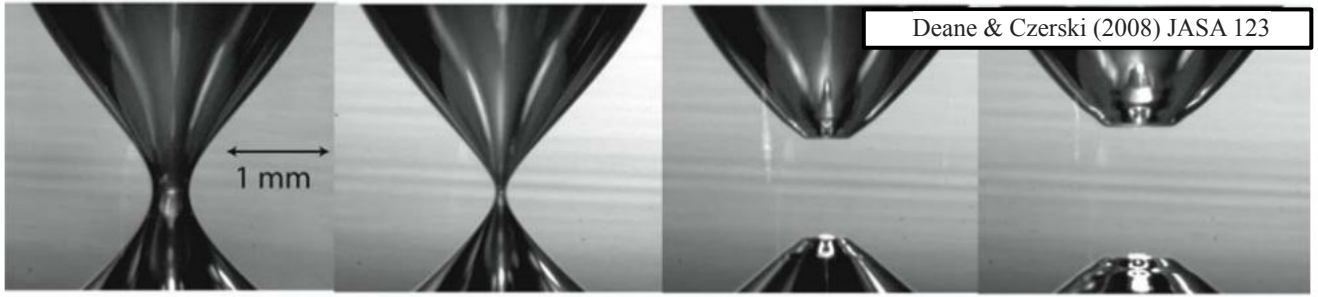
Riviere et al. (2021) JFM 917



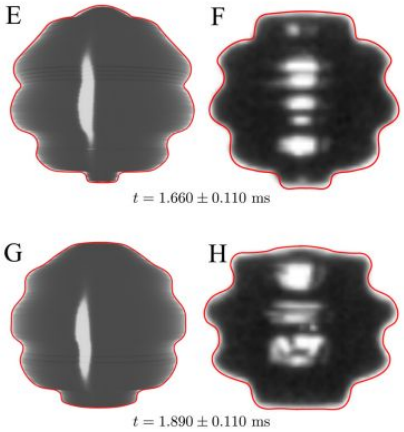
Small bubbles drawn into the depths…

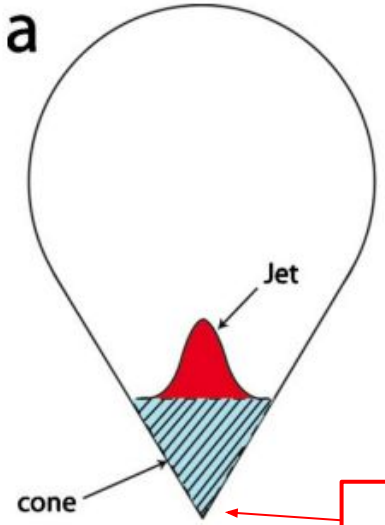
…and eventually dissolve.

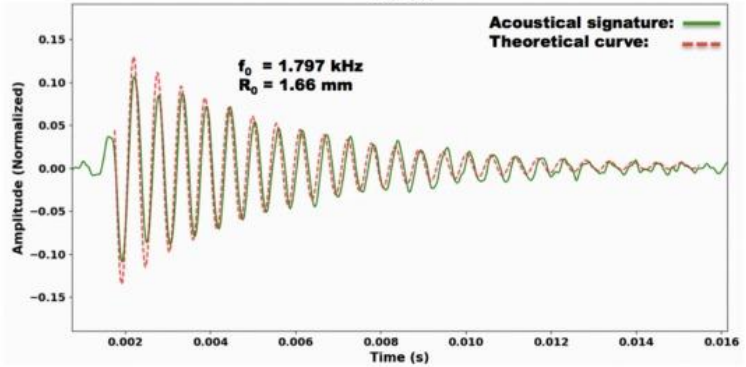
The sound of a breaking bubble



Deane & Czerski (2008) JASA 123





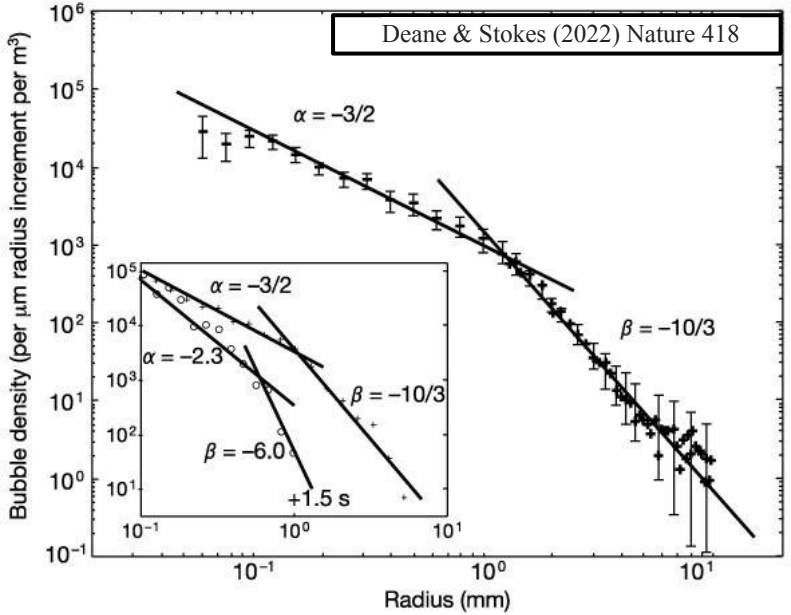


A singularity!

Bubbles of differing sizes



Berneray, this morning



Large bubbles - lower pitch, louder

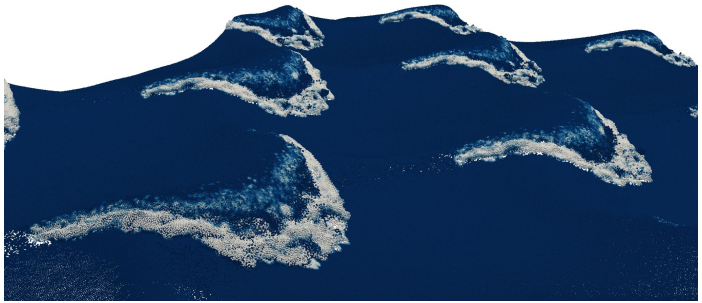
Smaller bubbles - higher pitch, quieter

Artists commission

- Artwork(s) inspired by connections and experiences with the sound of the sea.
- Media: (e.g.) photography, poetry, drawing, painting, printmaking.
- Budget: £1,000 including all materials, production and delivery.

The artwork(s) will be included in a small touring exhibition alongside scientific explanation and a specially created music & video work, incorporating scientific data and audio recordings of the seas surrounding the Outer Hebrides.

The exhibition will be initially staged in the cafe at Taigh Chearsabhagh summer 2026, and will hopefully be touring across the Outer Hebrides and possibly beyond through the following year.



Timeline

- Deadline for initial 1 page proposals, with links to reference images, will be October 31st.
- Shortlisted artist(s) notified by November 15th.
- Commissioned artist(s) notified by 30th November.
- Delivery date for the finished work: 1 May 2026.

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The University of Manchester

Sounds of the Sea

Jack King
University of Manchester

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