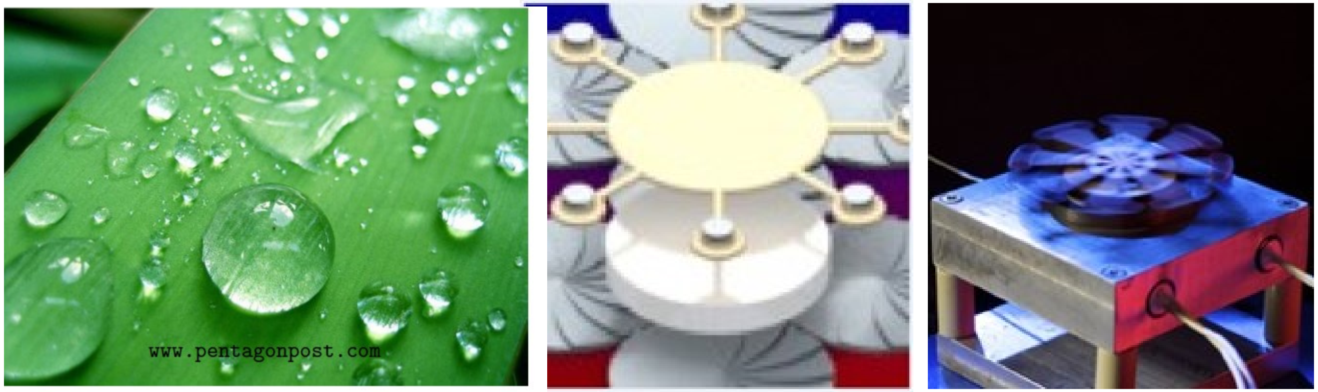
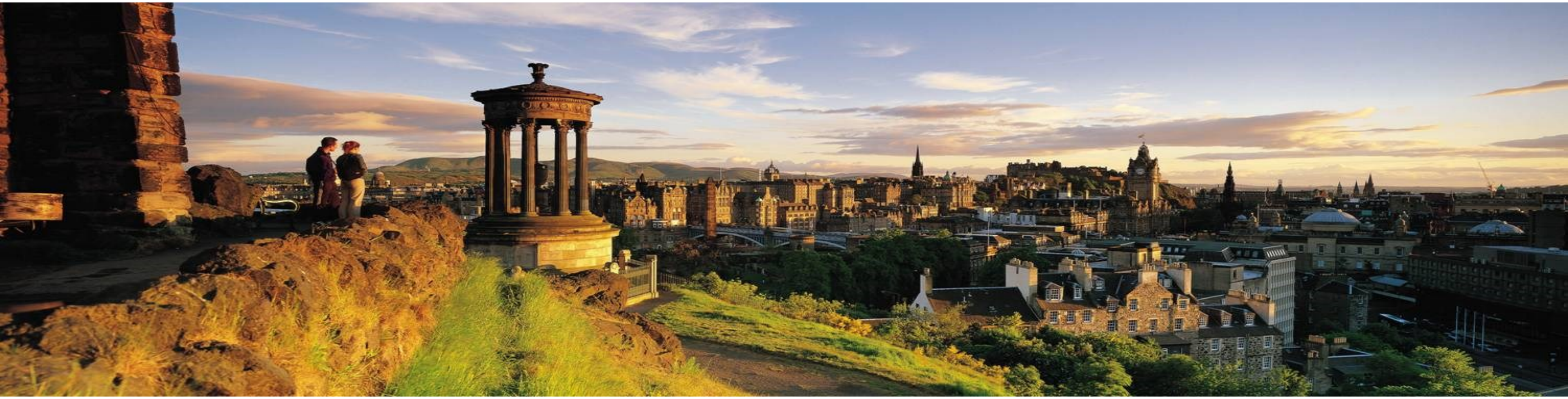
From wetting and evaporation of drops to **Leidenfrost engine**

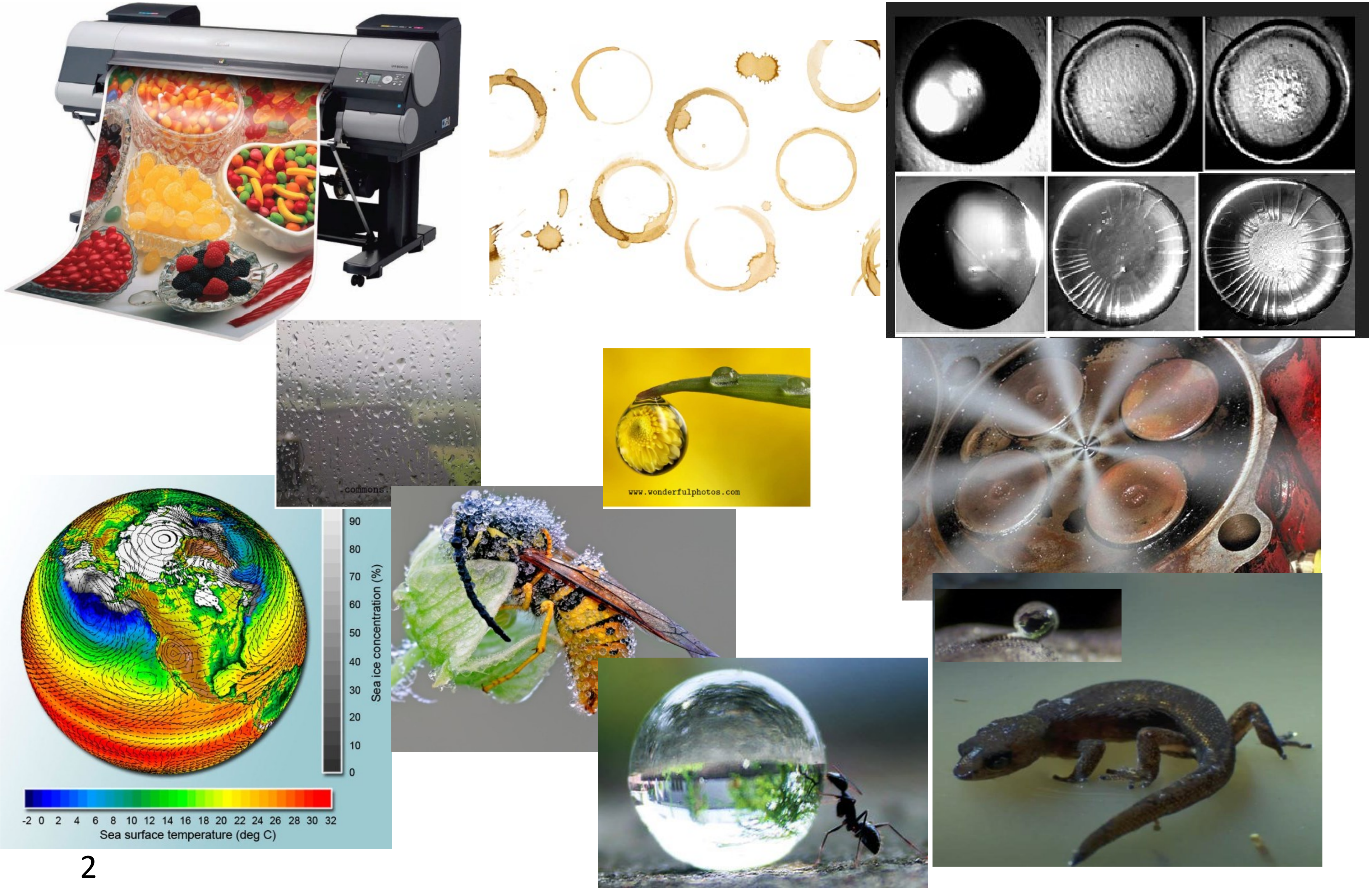
THE UNIVERSITY
of EDINBURGH



Prof. Khellil Sefiane, University of Edinburgh, UK
ksefiane@ed.ac.uk



Drops are everywhere



Contact lines and multiscales

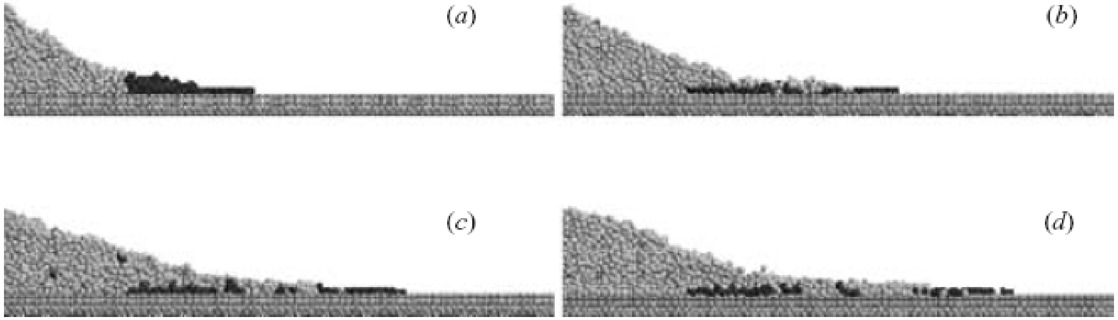
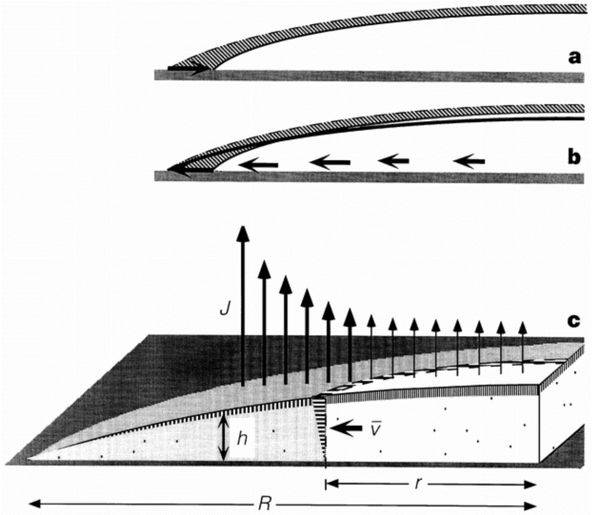
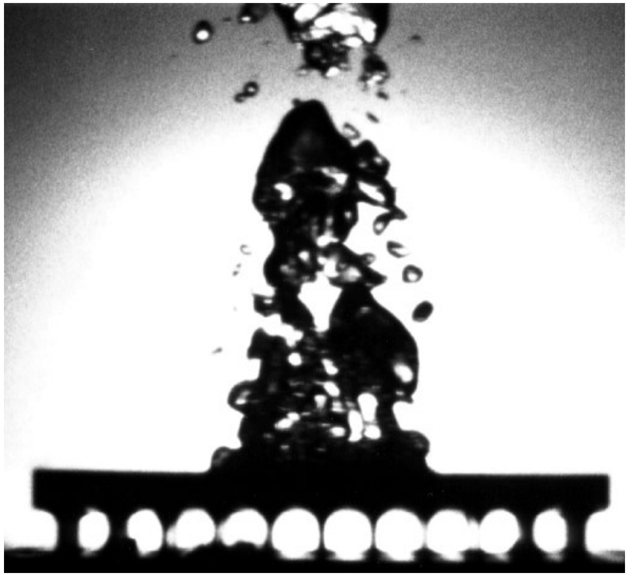


FIGURE 2. Snapshots of the droplet spreading process at (*a*) $t/t_{LJ} = 5000$, (*b*) 10 000, (*c*) 15 000, (*d*) 20 000. Particles in the precursor region in (*a*) are marked with a dark colour such that their subsequent motion can be tracked. The caterpillar-type motion first reported by Dussan V. & Davis is observed, as well as slipping motion close to the tip of the precursor.

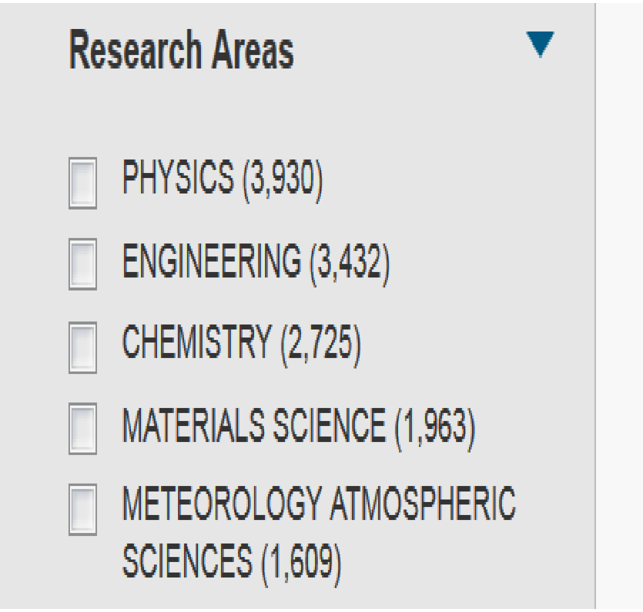
James Clerk Maxwell
Scotland (1831 - 1879)



NATURE,389, 23, 1997



Outline of presentation



Research Areas ▼

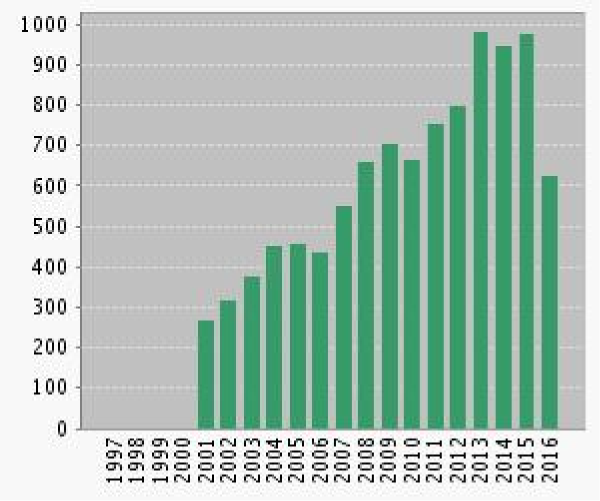
☐ PHYSICS (3,930)

☐ ENGINEERING (3,432)

☐ CHEMISTRY (2,725)

☐ MATERIALS SCIENCE (1,963)

☐ METEOROLOGY ATMOSPHERIC SCIENCES (1,609)



Drop AND Evaporation

1. Effect of substrate thermal properties
2. Instabilities and Hydrothermal waves
3. Lifetimes of drops
4. **Leidenfrost Engine**

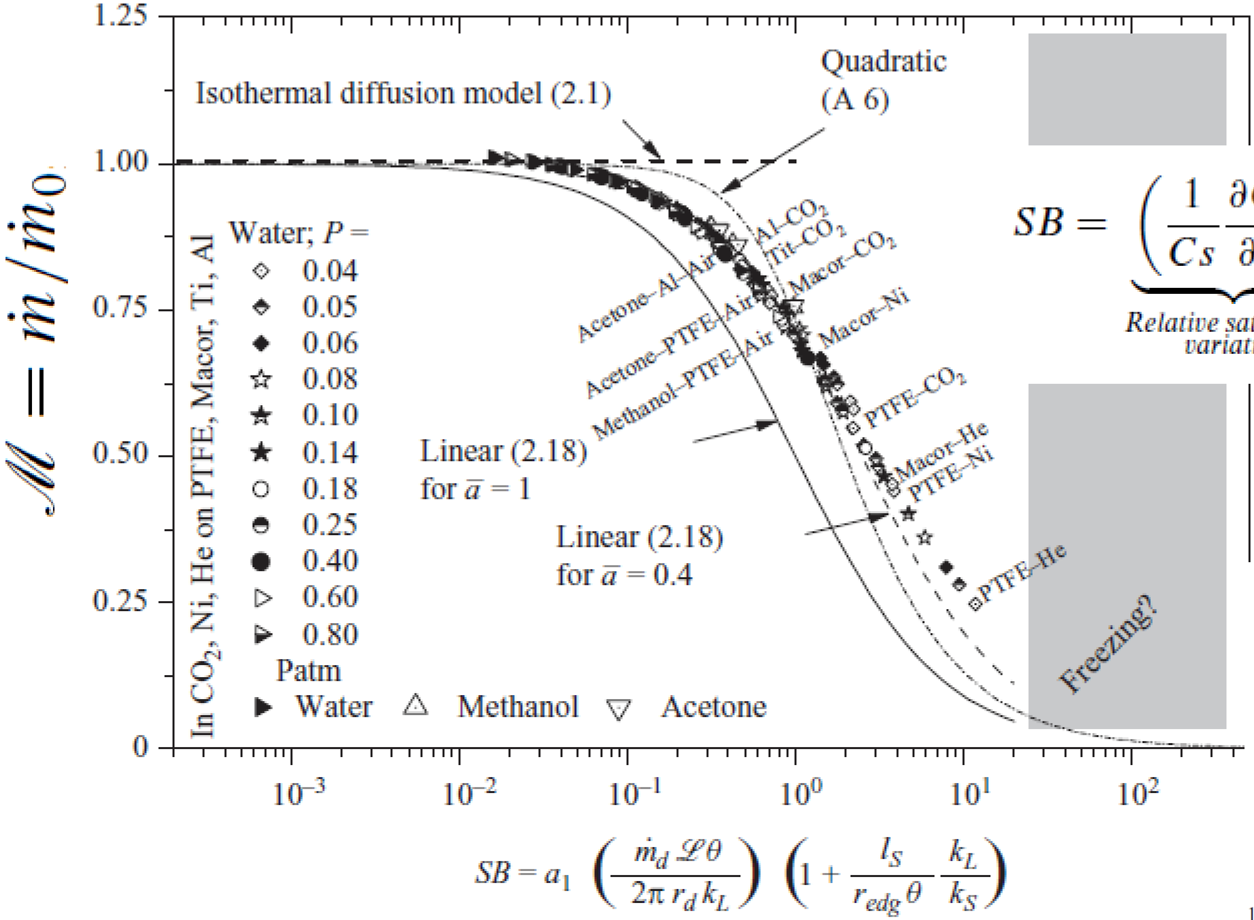
1. Effect of Substrate Thermal Properties On Drop Evaporation

A new dimensionless number for the effect of substi thermal properties

Journal of Fluid Mechanics.
p. 329-351, **2009.**

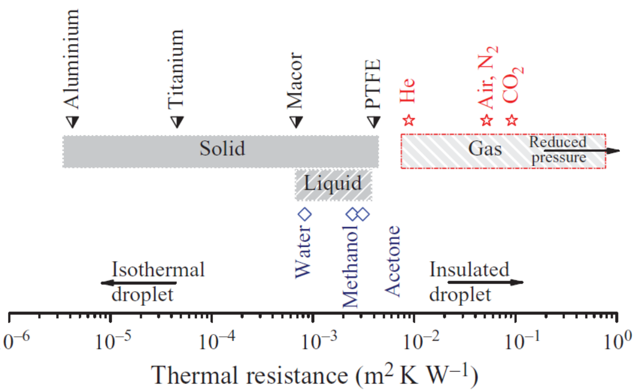
IOP Institute of Physics

Printing and Graphics Science Group Prize 2009



$$SB = \underbrace{\left(\frac{1}{C_S}\frac{\partial C_S}{\partial T}\right)}_{\text{Relative saturation variation}} \underbrace{\left(\frac{\dot m_d \mathfrak{L}}{k_L 2\pi r_d/\theta}\right)}_{\text{Resulting temperature difference}} \underbrace{\left(1+\frac{l_S}{l_L}\frac{k_L}{k_S}\right)}_{\text{Liquid–solid relative thermal resistance}}.$$

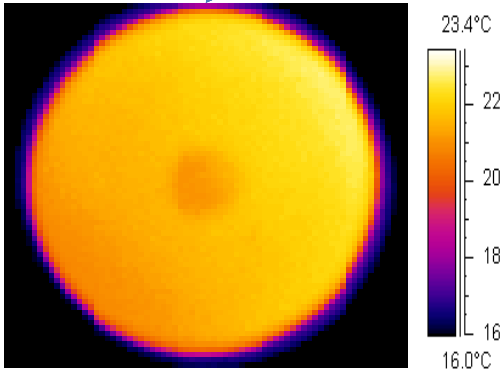
Journal of Fluid Mechanics.
p. 260-271. **2011.**

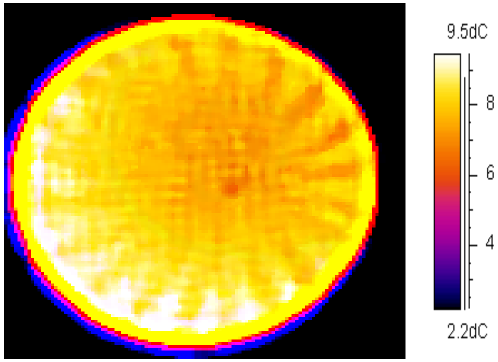


2. Instabilities and Hydrothermal waves in drops

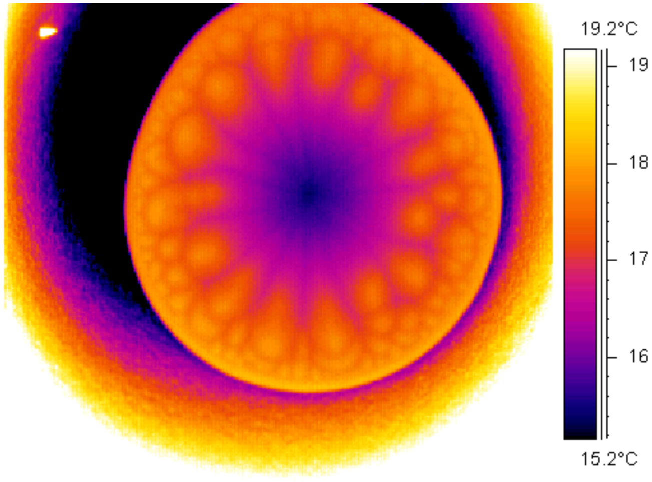
Sefiane *et al., APPLIED PHYSICS LETTERS*, **2008,** 93, 074103

Water (b. pt. 100°C): weak thermal activity



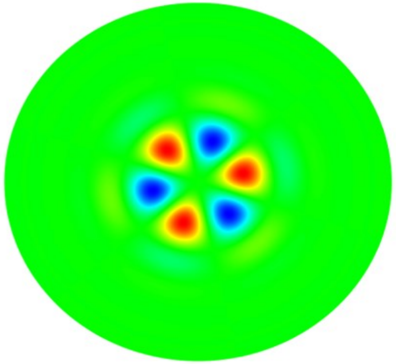


Methanol (b. pt. 64.7°C): thermal *waves*



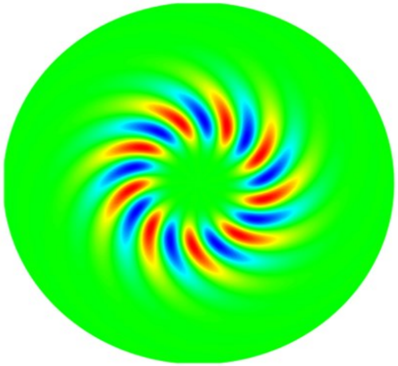
FC-72 (b. pt. 56°C): convective *rolls*

k=3, α=0.022



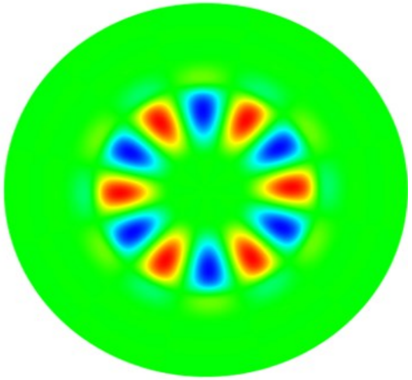
b) Re=100, Pr=1, t=25

k=9, α=0.064+0.088i



a) Re=100, Pr=1, t=2.5

k=6, α=0.145



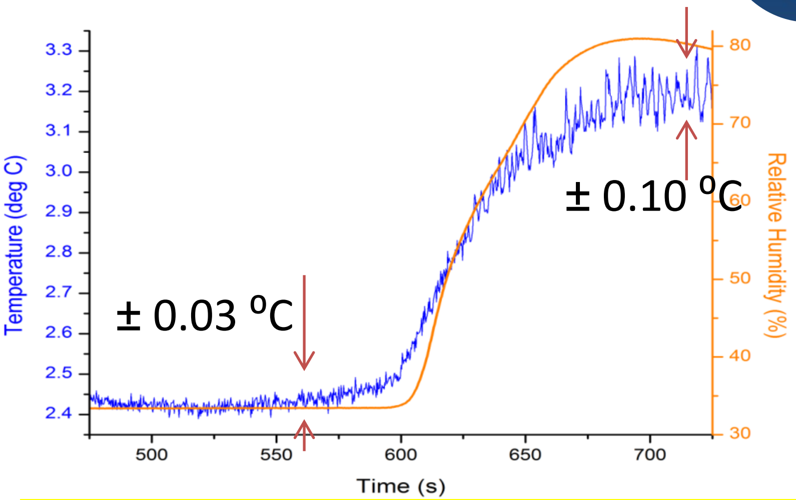
c) Re=20, Pr=7, t=125

Imperial College London

Langmuir, **2012**, *28* (31), p 11433–11439

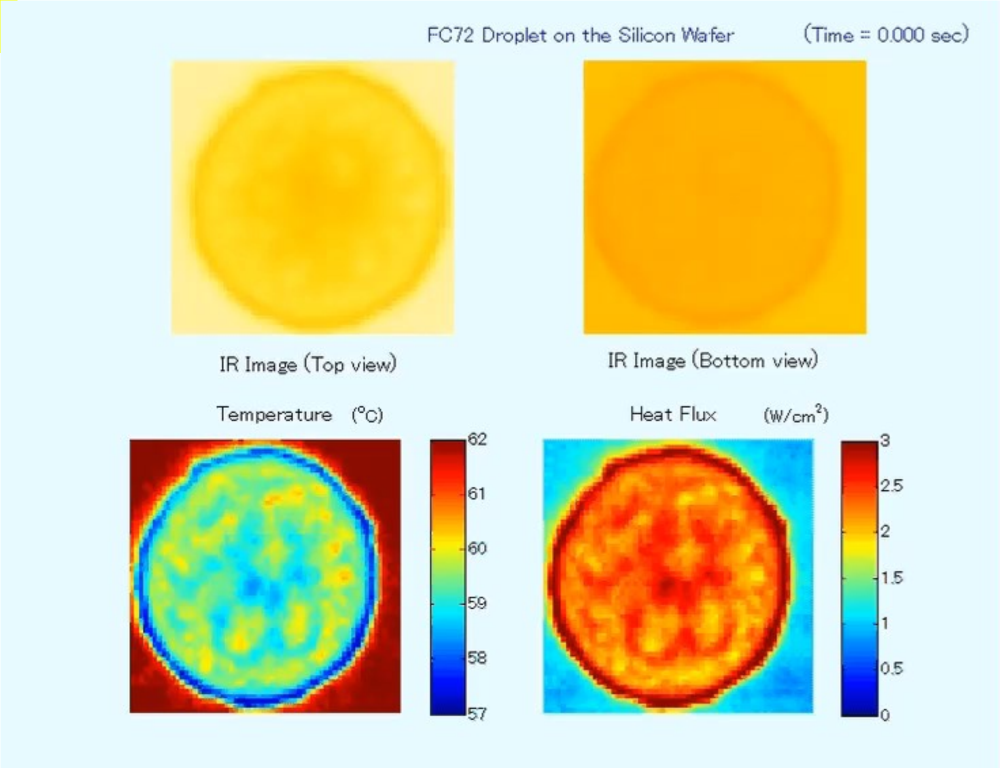
Effect of humidity on HTW in sessile drop evaporation

Mechanical & Industrial Engineering
UNIVERSITY OF TORONTO



Langmuir, **2013**, *29* (43), pp 13239–13250

Langmuir, **2013**, *29* (31), pp 9750–9760



UNIVERSITY OF MARYLAND

KYUSHU UNIVERSITY

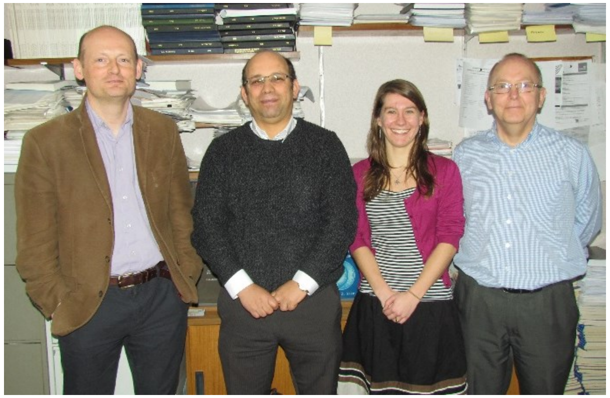
3. Lifetimes of drops..?


www.wonderfulphotos.com


commons.wikimedia.org


www.livescience.com


www.pentagonpost.com



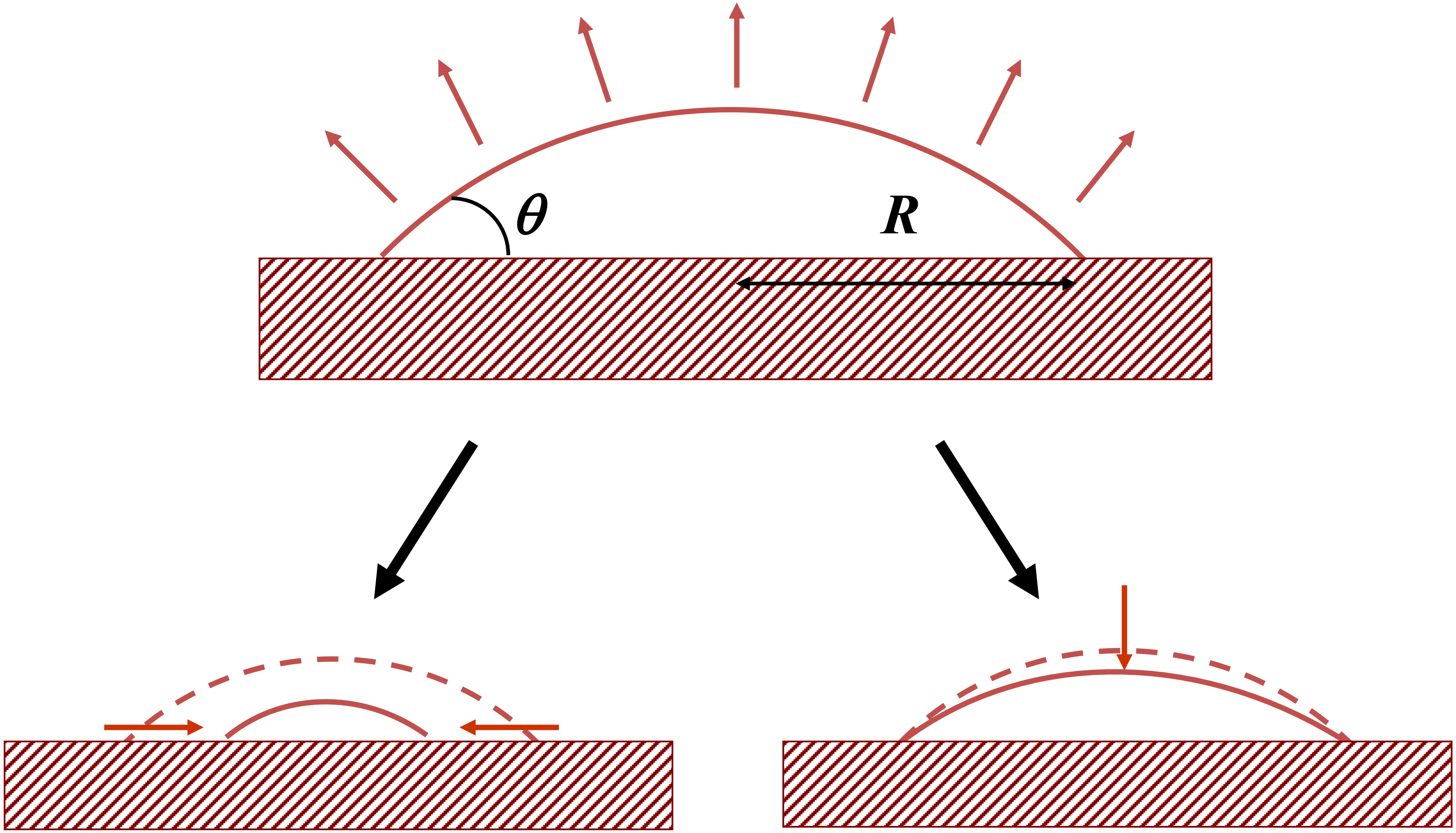
K. Sefiane[2]

[2]School of Engineering
University of Edinburgh, Edinburgh, UK

J. Stauber[1] S. K. Wilson[1] B. R. Duffy[1]

[1]Department of Mathematics and Statistics
University of Strathclyde, Glasgow, UK

…with evaporation?



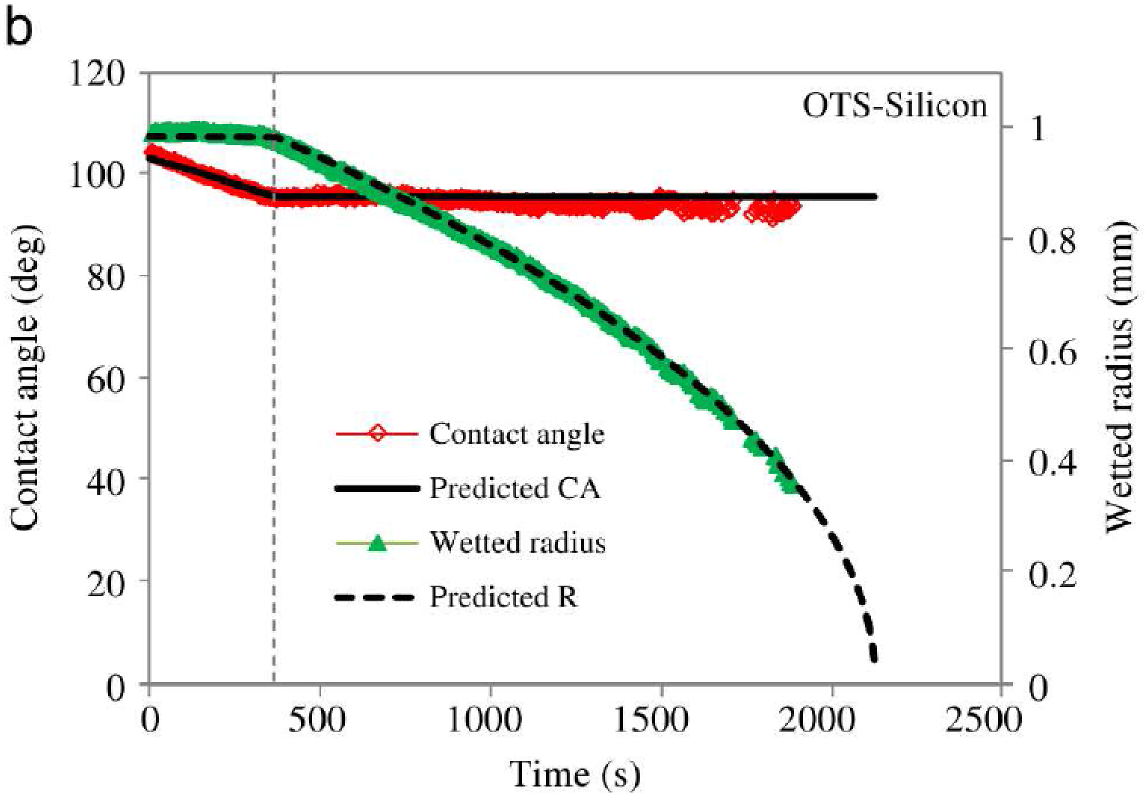
θ constant?

or ?

R constant?

Which mode leads to faster evaporation, i.e. shorter lifetime?

Stick-slip Mixed (M) Mode



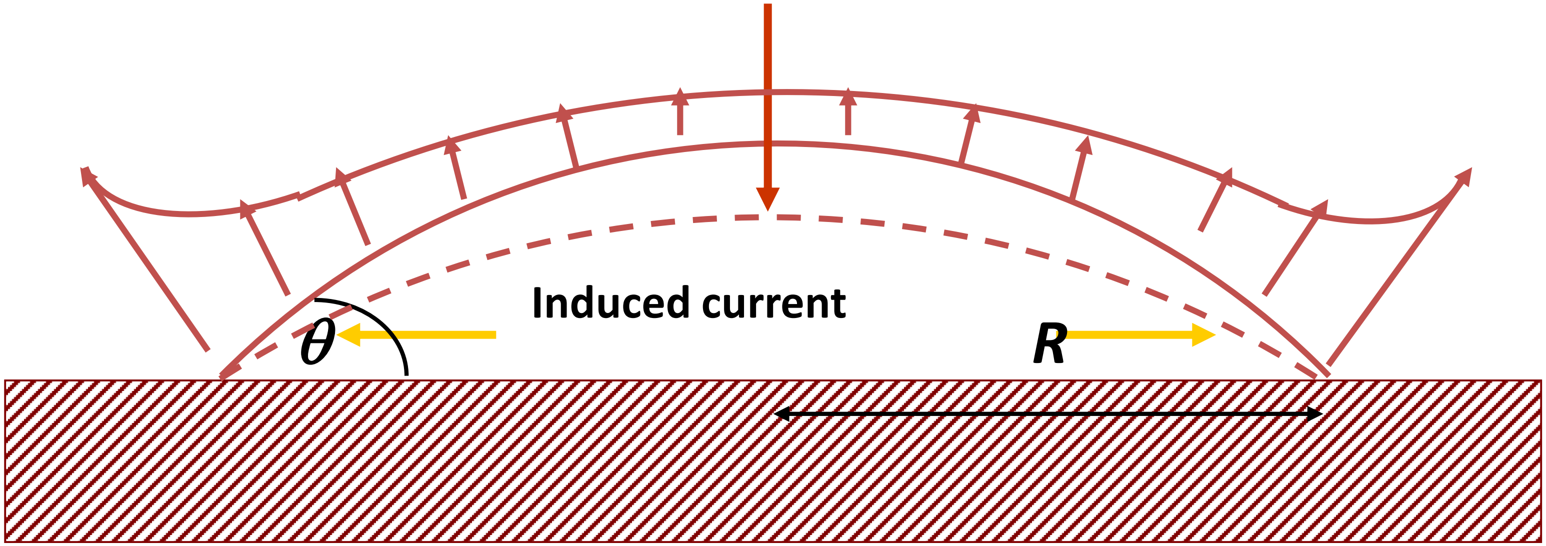
Nguyen et al, *Chem. Eng. Sci.*, **2012**, *69*, 522-529

Nguyen and Nguyen (2012): Transition angle θ^*, such that

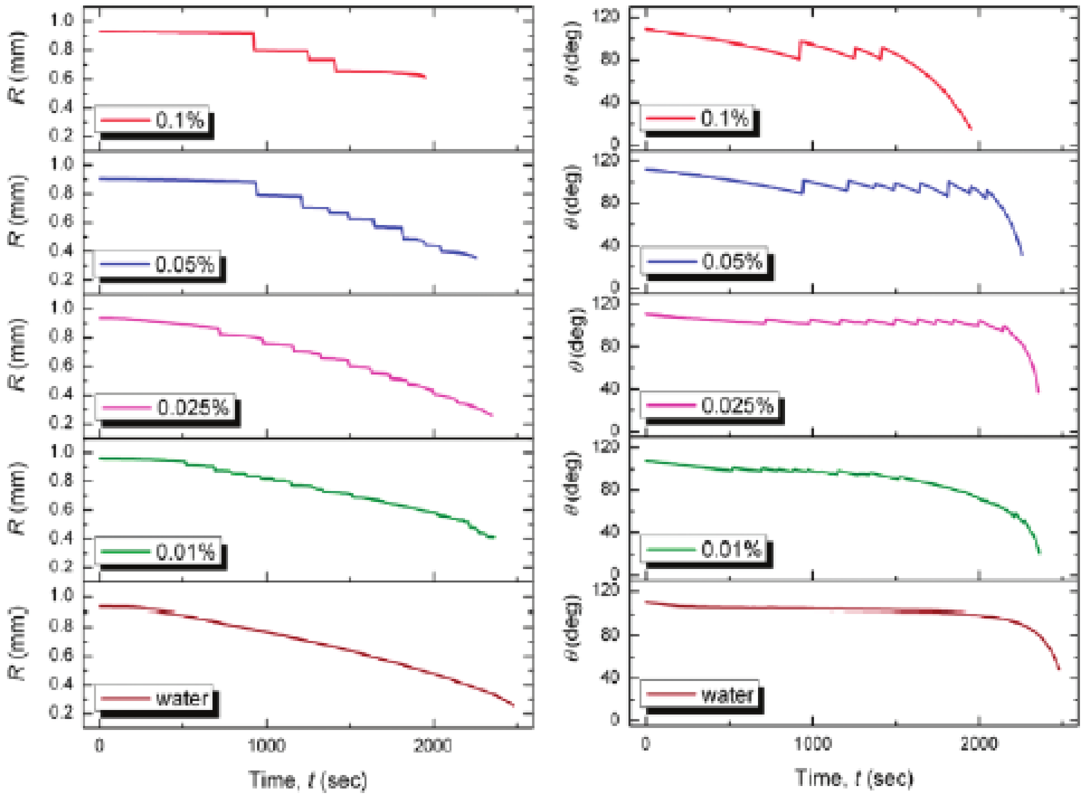
- For: $0 \leq \theta \leq \theta^*$: Constant Angle Mode
- For: $\theta^* \leq \theta \leq \pi$: Constant Radius Mode

Hydrodynamics

Evaporation is fn(radial distance)



Modelling stick-slip behaviour of evaporating sessile drop



Langmuir, (**2011**), *27* (21), 12834–12843

- Stick phase: contact radius, R, is constant, contact angle, θ, decreases to θ_{min}, constant.
- Slip phase (instant): R decreases, θ increases to θ_{max}, constant.
- Drop: Spherical cap
- Diffusion-limited evaporation model with arbitrary contact angle $0 < \theta \leq \pi$

Diffusion-Limited Model (e.g. Popov 2005)

- Spherical cap:

$$V = \frac{\pi R^3}{3} \frac{\sin\theta(\cos\theta + 2)}{(1 + \cos\theta)^2}$$

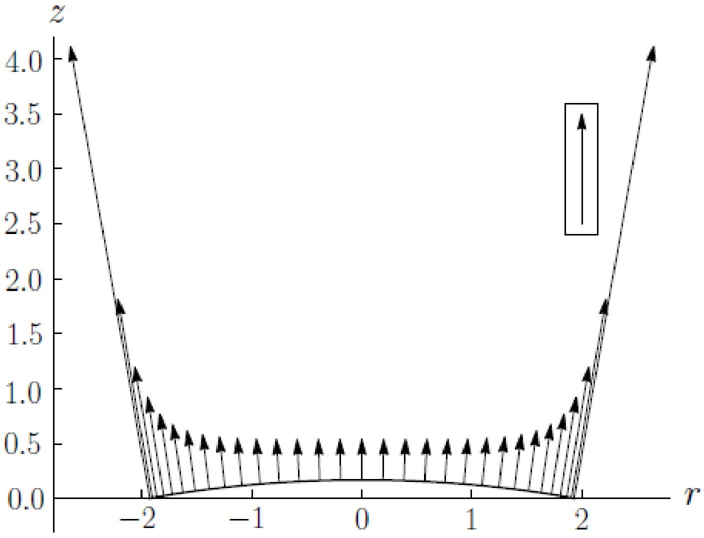
- Evaporative flux:

$$\begin{aligned} J(r) &= \frac{D(c_{\text{sat}} - c_\infty)}{R} \left[\frac{1}{2}\sin\theta + \sqrt{2}(\cosh\alpha + \cos\theta)^{3/2} \right. \\ &\times \left. \int_0^\infty \frac{\tau \cosh\theta\tau}{\cosh\pi\tau} \tanh\left[\tau(\pi - \theta)\right] P_{-1/2+i\tau}(\cosh\alpha)\mathrm{d}\tau \right], \end{aligned}$$

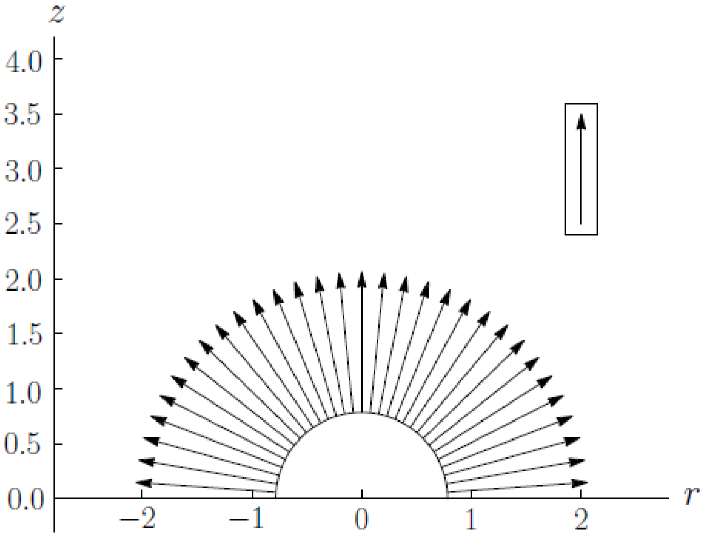
where $P_{-1/2+i\tau}(\cosh\alpha)$ is the Legendre function of the first kind of degree $(-1/2 + i\tau)$ and argument $\cosh\alpha$ and

$$r = \frac{R\sinh\alpha}{\cosh\alpha + \cos\theta}.$$

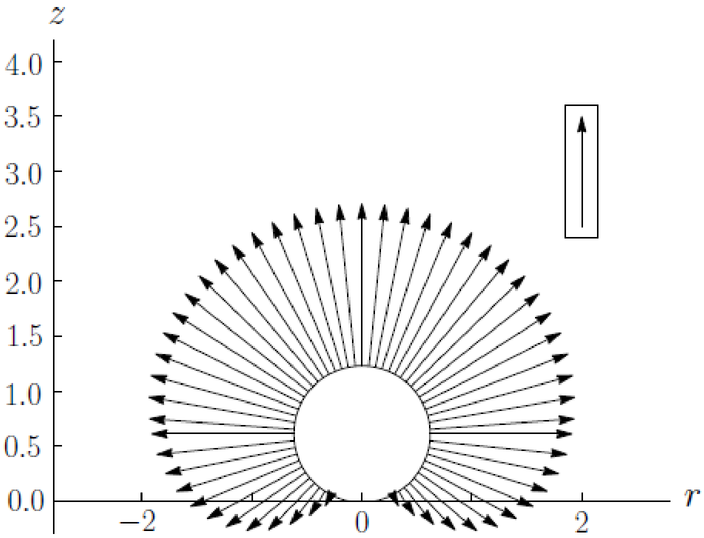
Diffusion-Limited Model: Evaporative Flux



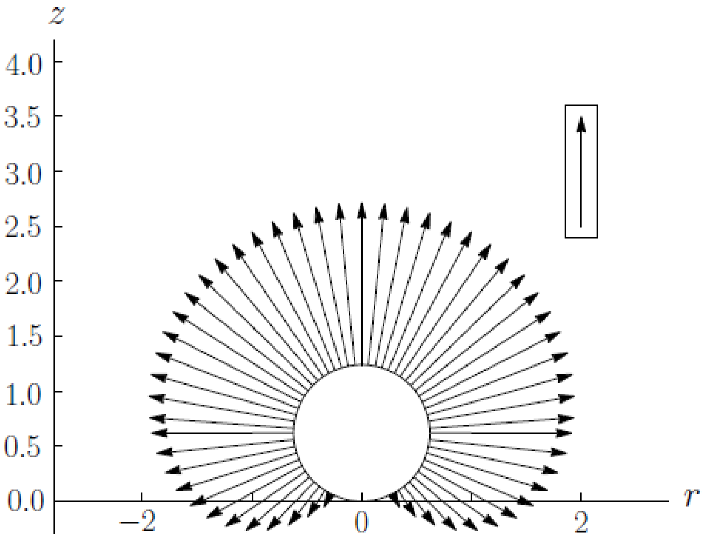
$\theta = 10°$



$\theta = 90°$



$\theta = 170°$



$\theta = 180°$

Rate of Loss of Volume

Diffusion-limited model:

$$\frac{\mathrm{d}V}{\mathrm{d}t} = \frac{1}{\rho}\int J\,\mathrm{d}A = -\frac{\pi R D(c_{\mathrm{sat}} - c_{\infty})}{\rho}\,\frac{g(\theta)}{(1+\cos\theta)^2}$$

where

$$g(\theta) = (1+\cos\theta)^2\left\{\tan\left(\frac{\theta}{2}\right) + 8\int_0^{\infty}\frac{\cosh^2\theta\tau}{\sinh 2\pi\tau}\tanh\left[\tau(\pi-\theta)\right]\mathrm{d}\tau\right\}$$

A: surface of the drop
D: diffusion coefficient of vapour in the air
ρ: density of fluid
c_{sat}: (saturated) vapour concentration at the interface
c_{∞}: vapour concentration far from the interface

$$V = \frac{\pi R^3}{3}\,\frac{\sin\theta(\cos\theta+2)}{(1+\cos\theta)^2}$$

Droplet Lifetimes

- Constant Radius (CR) Mode:

$$t_{\mathrm{CR}} = \left(\frac{2(1+\cos\theta_0)^2}{\sin\theta_0(\cos\theta_0+2)} \right)^{2/3} \int_0^{\theta_0} \frac{2\,\mathrm{d}\theta}{g(\theta)}$$

- Constant Angle (CA) Mode:

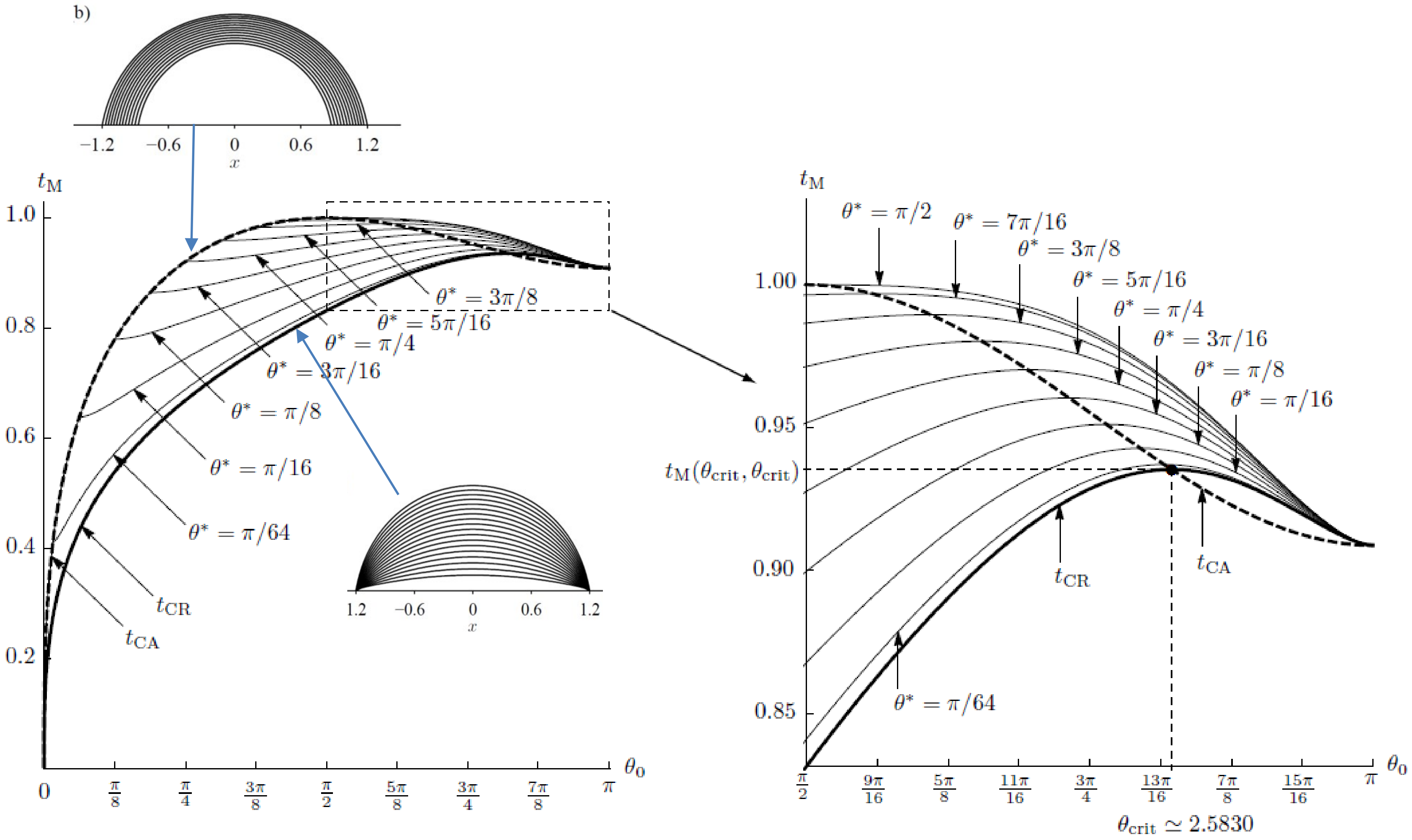
$$t_{\mathrm{CA}} = \left(\frac{2(1+\cos\theta_0)^2}{\sin\theta_0(\cos\theta_0+2)} \right)^{2/3} \frac{\sin\theta_0(\cos\theta_0+2)}{g(\theta_0)}$$

- Stick-Slide (SS) Mode ($\theta_0 > \arccos(1-c)$):

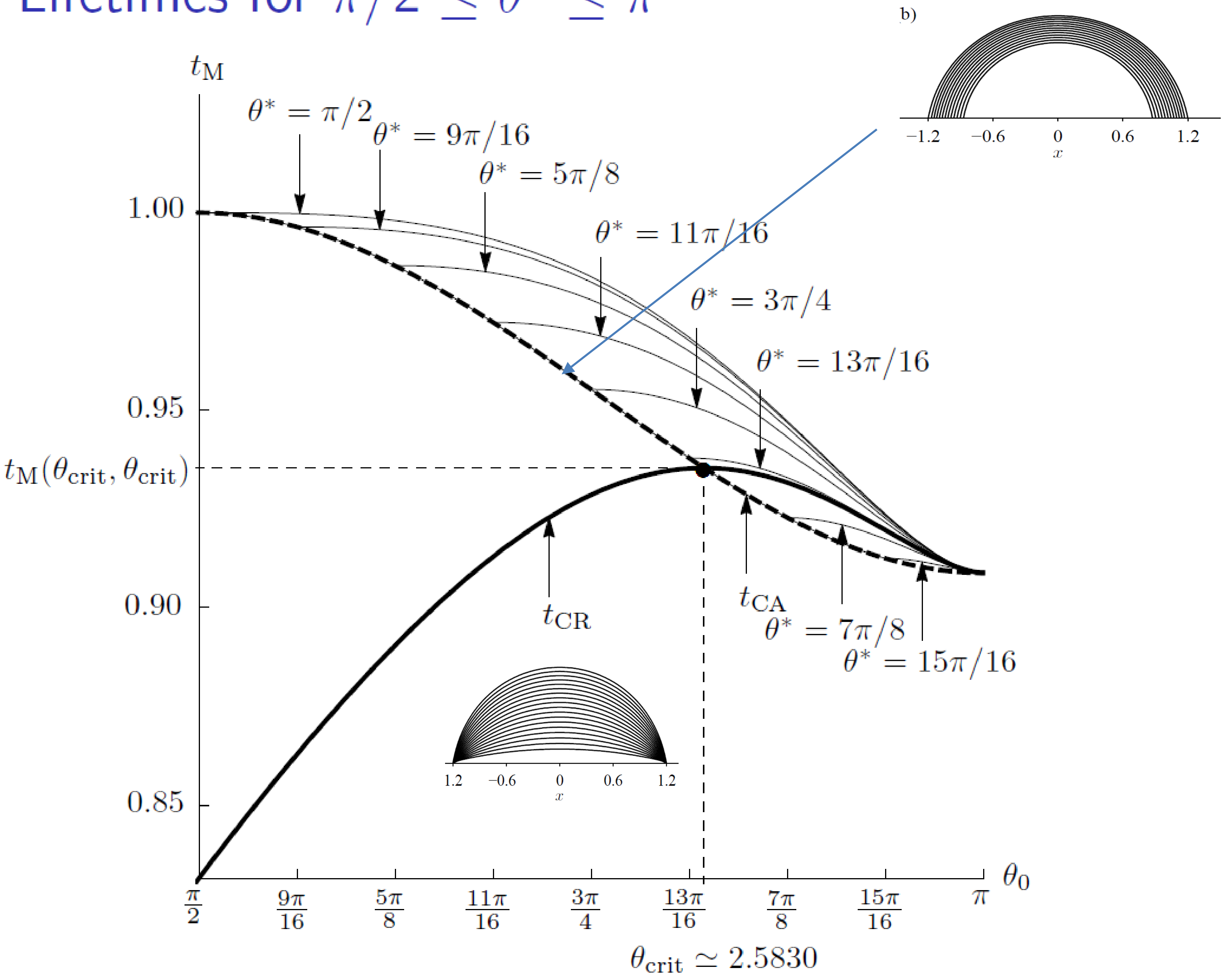
$$t_{\mathrm{SS}} = \left(\frac{2(1+\cos\theta_0)^2}{\sin\theta_0(\cos\theta_0+2)} \right)^{2/3} \left[\int_{\theta^*}^{\theta_0} \frac{2\,\mathrm{d}\theta}{g(\theta)} + \frac{\sin\theta^*(2+\cos\theta^*)}{g(\theta^*)} \right]$$

where $\theta^* = \arccos(c + \cos\theta_0)$

Droplet Lifetimes for $0 \leq \theta^* \leq \pi/2$

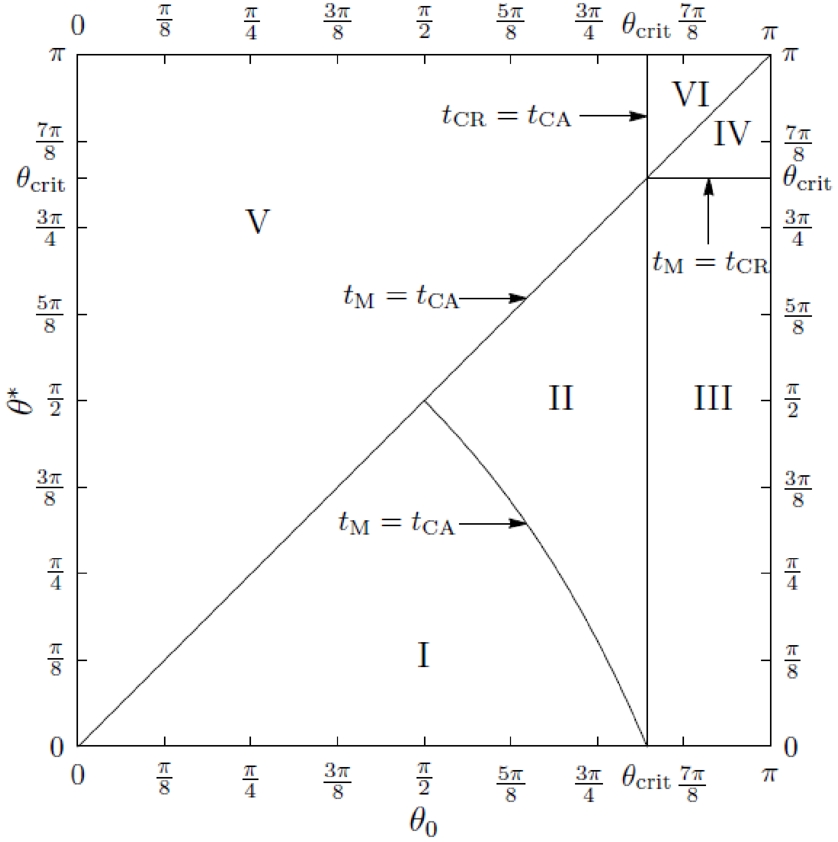


Droplet Lifetimes for $\pi/2 \le \theta^* \le \pi$



Comparing Lifetimes in all Three Modes of Evaporation

A Universal Map

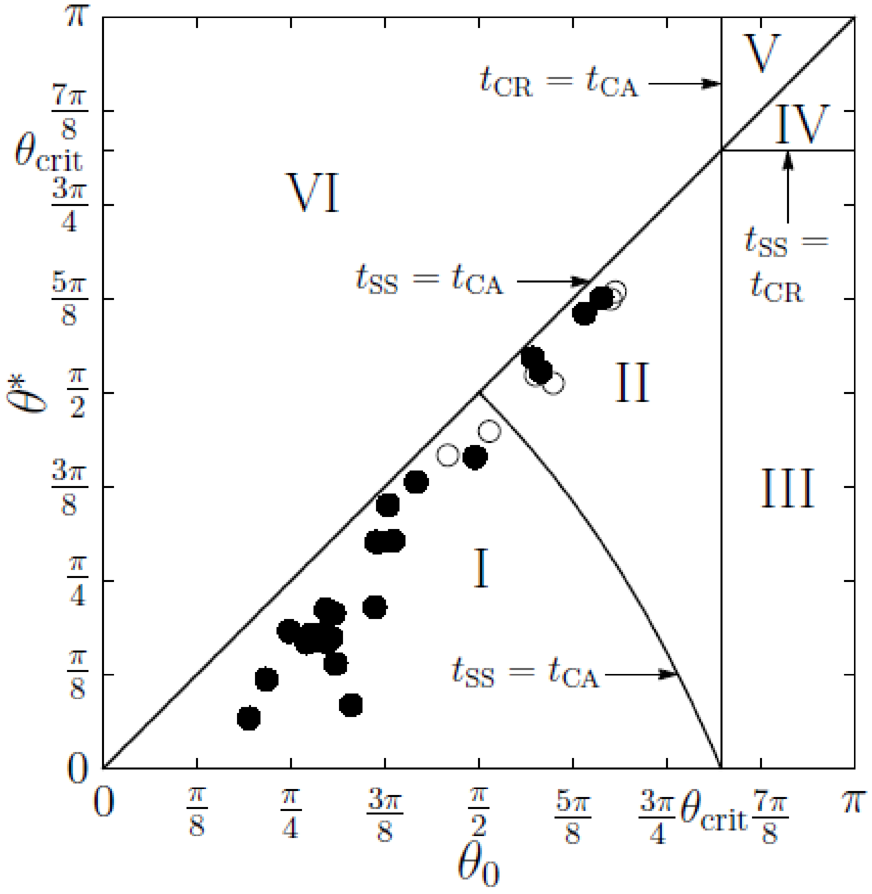


- Region I: $t_{\mathrm{CR}} < t_{\mathrm{M}} < t_{\mathrm{CA}}$
- Region II: $t_{\mathrm{CR}} < t_{\mathrm{CA}} < t_{\mathrm{M}}$
- Region III: $t_{\mathrm{CA}} < t_{\mathrm{CR}} < t_{\mathrm{M}}$
- Region IV: $t_{\mathrm{CA}} < t_{\mathrm{M}} < t_{\mathrm{CR}}$
- Region V: $t_{\mathrm{CR}} < t_{\mathrm{M}} = t_{\mathrm{CA}}$
- Region VI: $t_{\mathrm{M}} = t_{\mathrm{CA}} < t_{\mathrm{CR}}$

Comparing Experimental Data with Model Predictions (2)

	θ_0	θ^*	t_{M} expt	t_{M} model	Diff. (%)
B-M 1	56°	25°	0.9235	0.84513	−8.49
B-M 2	59°	15°	0.8233	0.80737	−1.93
Li 1	103°	98°	1.0278	0.99792	−2.91
Li 2	83°	75°	1.0166	0.99303	−2.32
Li 3	89°	75°	0.9895	0.99369	0.43
Li 4	75°	69°	0.9688	0.98493	1.66
Li 5	69°	54°	0.9729	0.95756	−1.58
Li 6	65°	54°	0.9547	0.95531	0.06
Li 7	53°	38°	0.8994	0.89680	−0.29
Li 8	45°	33°	0.8723	0.86515	−0.82
Li 9	35°	12°	0.6706	0.71640	6.83
Bor 1	81°	68°	1.0156	0.98550	−2.96
Bor 2	82°	60°	0.9527	0.97443	2.28
Yu	115°	109°	0.9846	0.98981	0.53

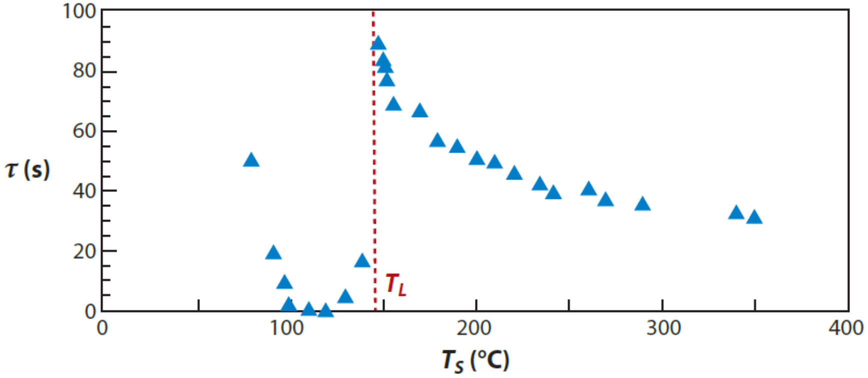
Comparing Lifetimes in all Three Modes of Evaporation



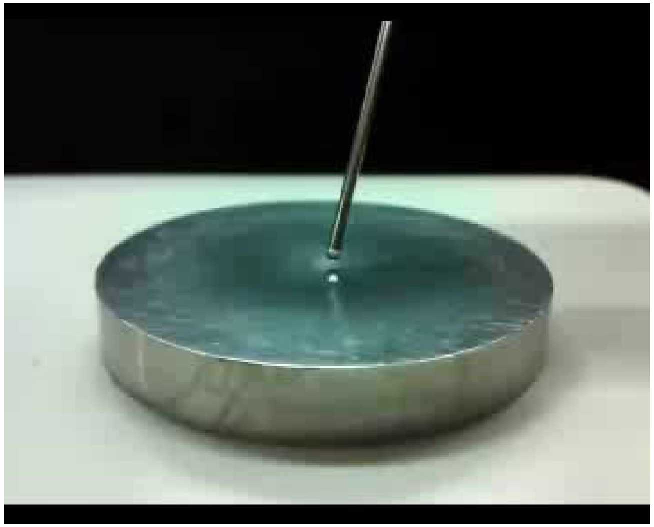
- Region I: $t_{CR} < t_{SS} < t_{CA}$
- Region II: $t_{CR} < t_{CA} < t_{SS}$
- Region III: $t_{CA} < t_{CR} < t_{SS}$
- Region IV: $t_{CA} < t_{SS} < t_{CR}$
- Region V: $t_{SS} = t_{CA} < t_{CR}$
- Region VI: $t_{CR} < t_{SS} = t_{CA}$

Journal of Fluid Mechanics.
Vol. 744, **2014.**

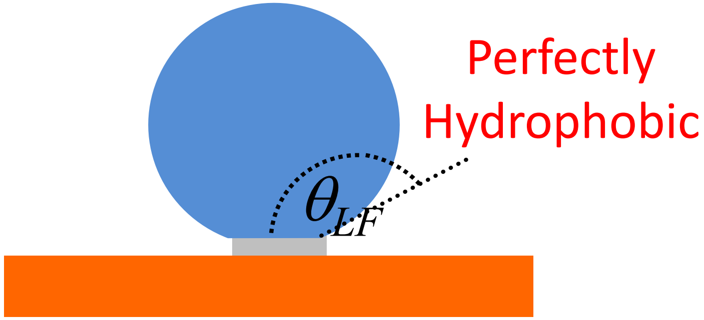
Leidenfrost Effect



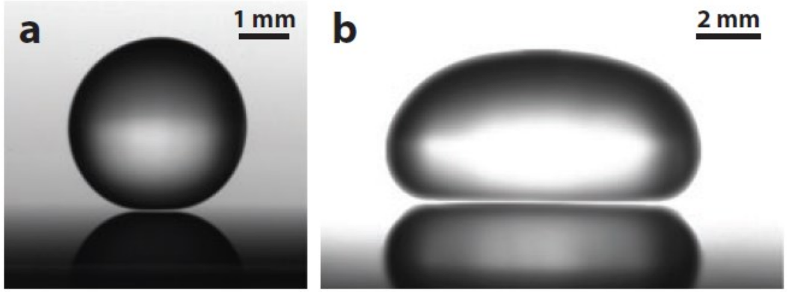
Lifetime of a droplet on a polished metal plate



<u>Leidenfrost State</u>



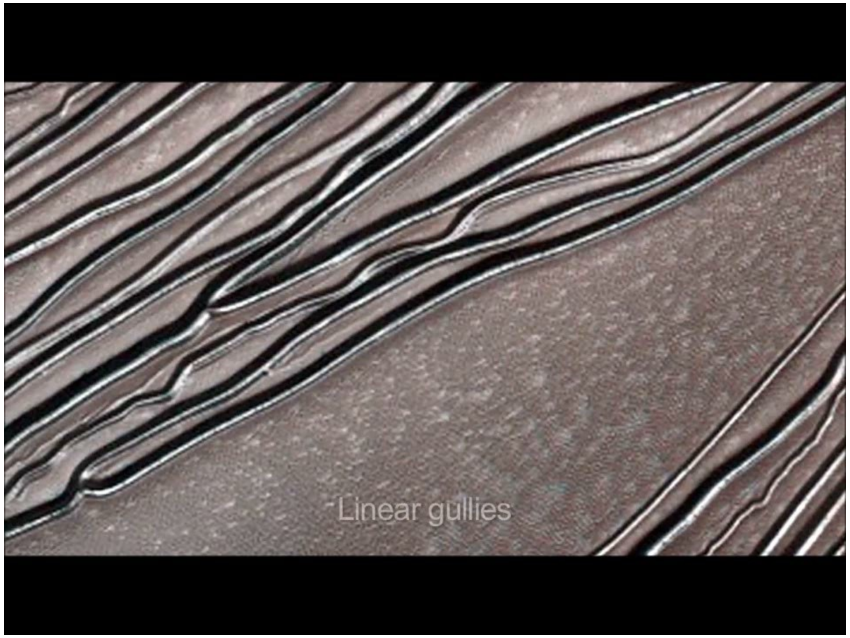
Vapour Supported and Gravity Flattened



Droplets on a hot metal plate (300 ^oC) (Quéré, 2013)

Quéré, D. Annu. Rev. Fluid. Mech. (2013) <u>45</u> 197.

Space Exploration



Motivation

Linear Gullies on Mars

1. Hypothesis: Sliding dry ice blocks due to seasonal temperature variations
2. Tested idea on slopes of dunes in the desert
3. Sublimation Leidenfrost effect

Diniega *et al*, *Icarus* (2013) **225**, 526-537. Jet Propulsion lab video archive – “Dry Ice Moves on Mars - June 11, 2013” (Truncated version from http://mars.nasa.gov/mro/multimedia/videoarchive/)

Extreme Environments

1. Large temperature differences exist
2. Deep space has abundance of locally available dry ices, e.g. H_2O, CO_2, CH_4
3. Idea of sublimation for use in micro-thrusters is an established space concept
4. MEMS micro-heat engines for scavenging waste energy (e.g. Epstein et al, IEEE Transducers 1997, Fréchette et al, PowerMEMS 2003 Conferences)

Turbine-Like Substrates

Linear Ratchets – Droplets and Solid Ices

1. Droplet: Linke et al, *Phys. Rev. Lett.* (2006) **96**, 154502
2. Dry ice: Lagubeau et al, *Nat. Phys.* (2011) **7**, 395–398
3. Substrate: Asymmetric textured
4. Vapor: Rectified vapour flow

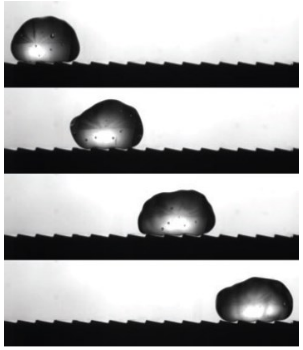
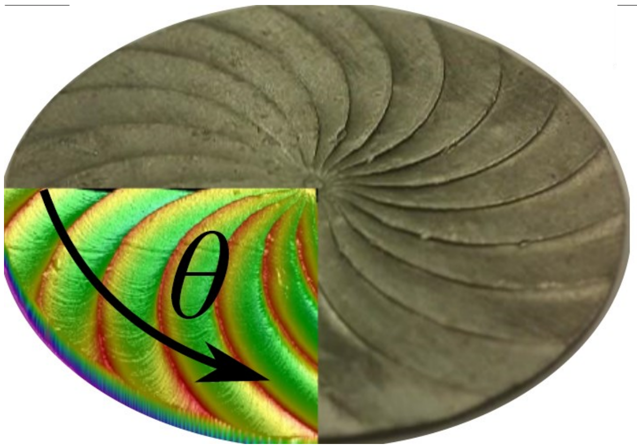


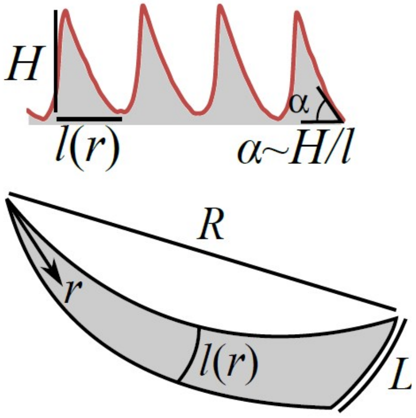
Image: Quéré (2013)

Image: Lagubeau et al (2011)

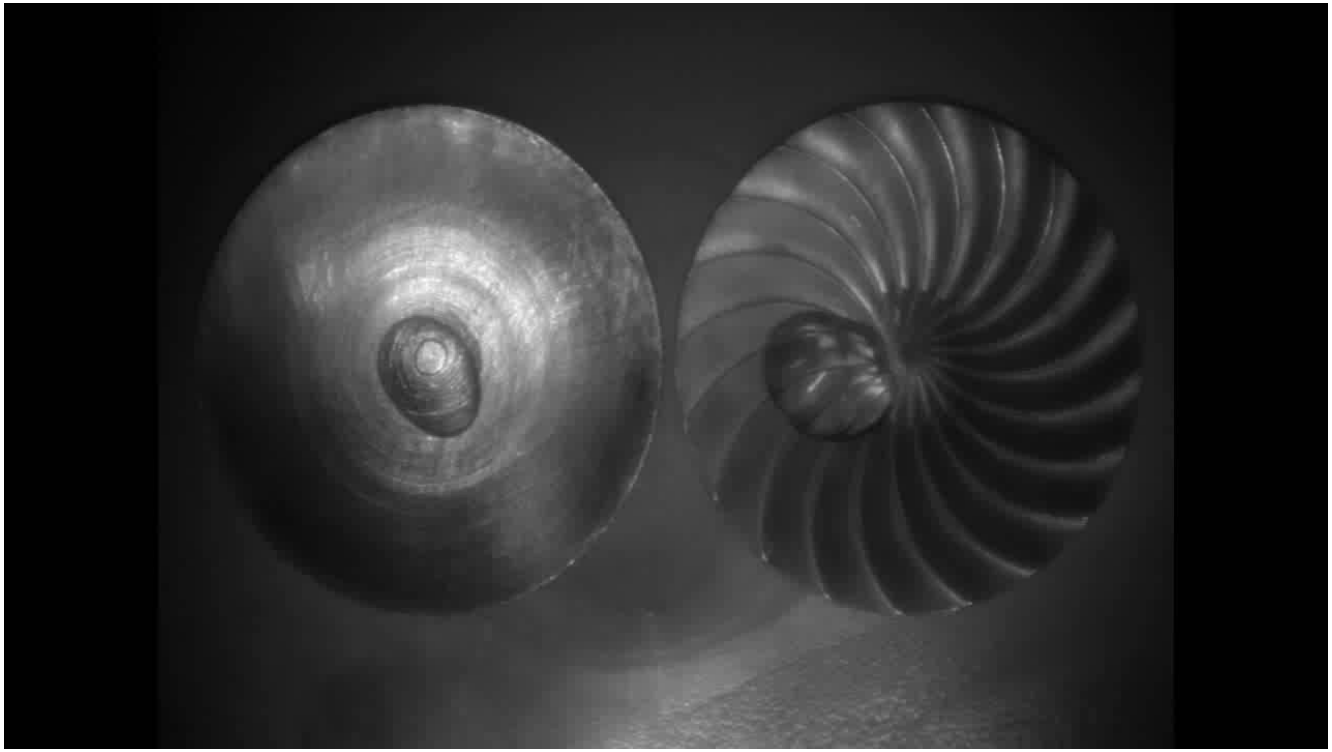
Our Turbine-Like Substrates

1. CNC manufactured turbine-like aluminium substrates
2. Based on axial gas turbine designs
3. $R=0.75$-2 cm, $N=10, 20, 30$





Orbiting and Spinning Droplets



Droplets on Turbine-Like Substrates

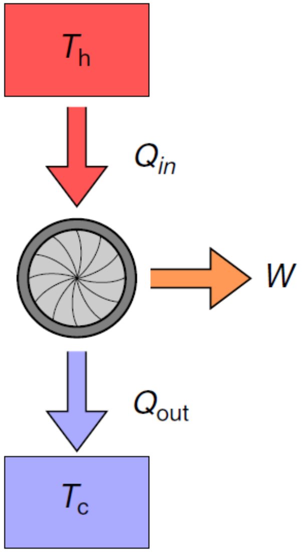
1. Rotation in an orbital fashion is possible
2. Spinning on their axis is possible
3. Difficult to stabilize

Sublimation Heat Engine Concept

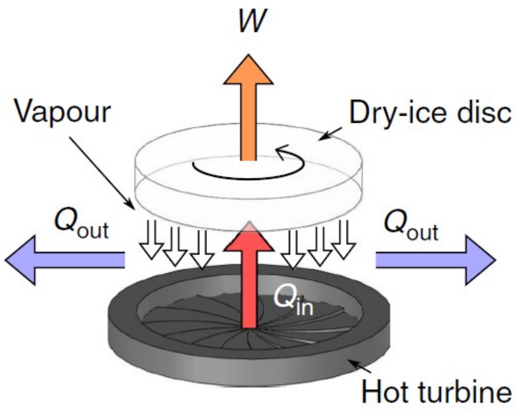
Sublimation Thermal Cycle

1. Sublimation (solid-vapor) equivalent to the Rankine cycle used in steam powered engines
2. The working substance is a solid (e.g. CO_2 but could be other ices such as H_2O or CH_4)
3. Harvest thermal energy Q_{in} via difference in temperature between reservoirs at T_h and T_c
4. Released vapor is rectified to produce mechanical work, W
5. Cooling releases Q_{out} to surroundings
6. Maximum theoretical efficiency limited by Carnot engine efficiency $\varepsilon = 1 - T_c/T_h \approx 1 - T_c/T_{ave} \approx 0.67$

Principle



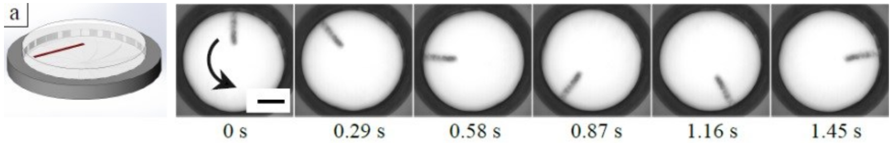
Realization

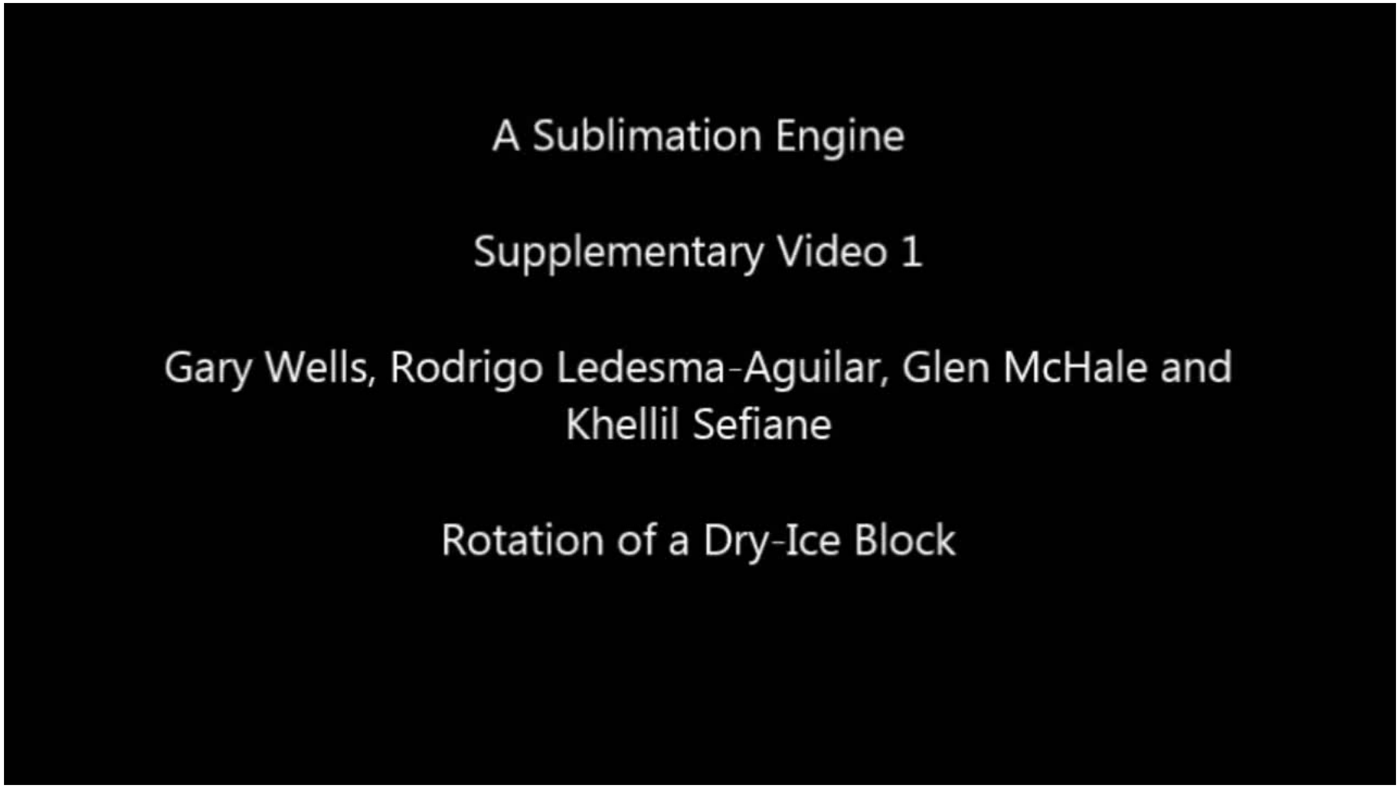


Efficiency: $\varepsilon = W/Q_{in}$

Wells, et al. Nature Commun.. (2015) 6 6390.

Rotational Motion via Sublimation





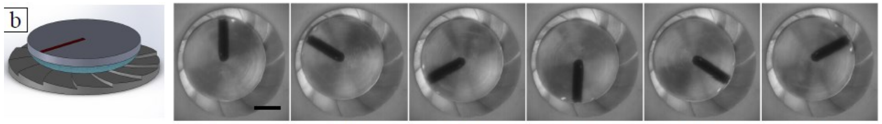
A Sublimation Engine

Supplementary Video 1

Gary Wells, Rodrigo Ledesma-Aguilar, Glen McHale and
Khellil Sefiane

Rotation of a Dry-Ice Block

Rotation via Droplet Coupled Disks



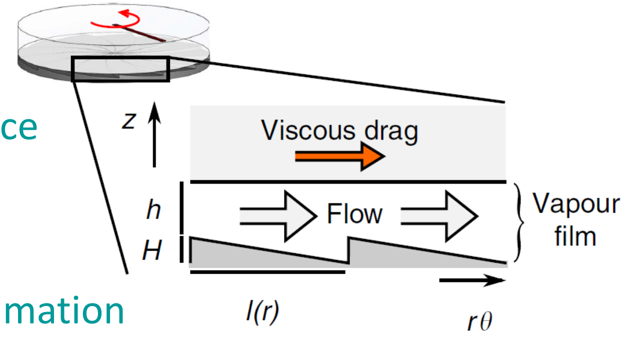
0 s 0.16 s 0.32 s 0.48 s 0.64 s 0.80 s

Theoretical Model

Levitation and Torque

Follow approach by Quéré and co-workers (2003-2013):

- Estimate rate of evaporation from surface of levitating dry ice
- Energy flux across vapour layer by conduction
- Rectified vapour flow induces a net viscous drag
- $Re<1$ in radial and angular directions ⇒ Lubrication approximation



Surface height, $h(r,\theta)$, variation:

- Varies speed of release of vapor
- Assume teeth height is small ($\xi = H/h_o << 1$) allows a solution: $h(\theta)=h_o(1+\xi R\theta\tan\alpha/H)$
- Perturbative solution in ξ for pressure gives leading order: $p_o(r)=p_{atm}+3\eta v_{no}(R^2-r^2)/h_o^3$
- Critical mass for rotation when vapor layer is ~ depth of teeth: $m_c \propto \rho_f l_{LF}^3(R/H)^3$
  where Leidenfrost length scale characterizes vapour pressure to weight of rotor ($f = fuel$)
- Torque (consistent with linear ratchet) is: $\tau_{z0} \propto \eta v_{no} R^4 \tan^3\alpha/h_o^5 N^4$
- Total torque over rotor is: $\Gamma \propto (m/l_{LF})^{3/2} R \tan^3\alpha/\rho_f N^4$

Key Test Equations

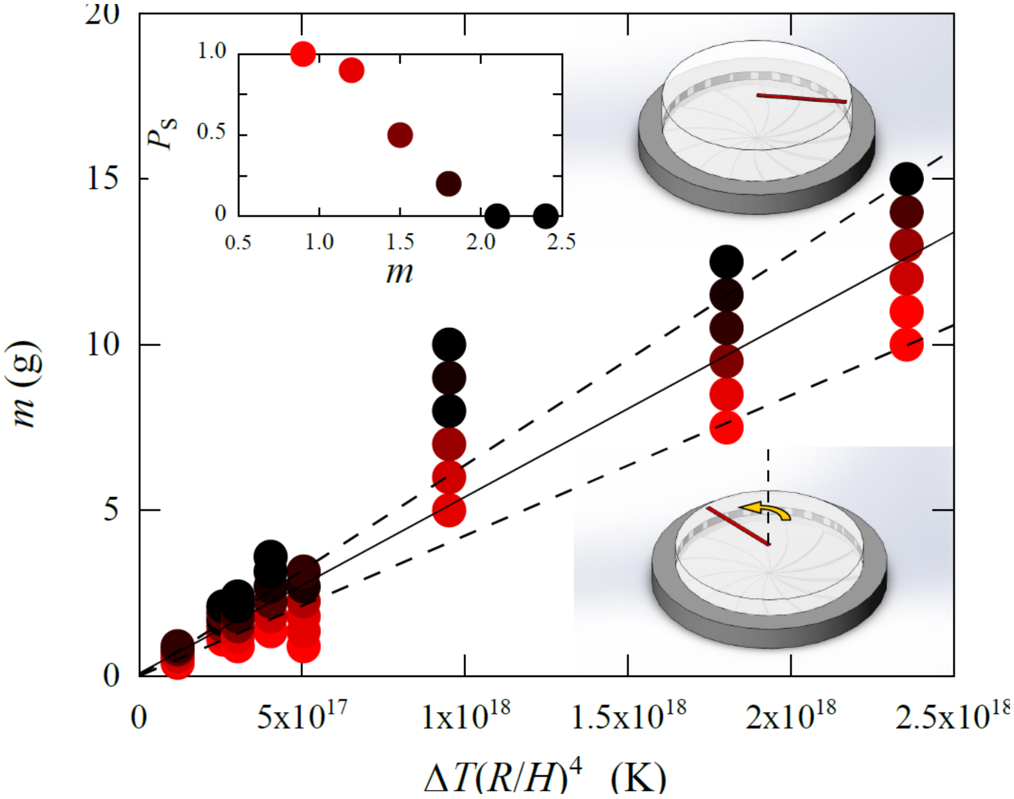
$m_c \propto \rho_f l_{LF}^3 (R/H)^3$ and $\Gamma \propto (m/l_{LF})^{3/2} R \tan^3\alpha/\rho_f N^4$

Physical Interpretation of Torque

- Torque increases with mass of dry ice (thinner vapor layer and more drag)
- Torque increases as radius increases (moment arm and surface area)
- Torque increases as inclination angle of teeth increase (more rectification of vapor flow)
- Torque decreases with number of teeth - these set periodicity of pattern $L=2\pi R/N$

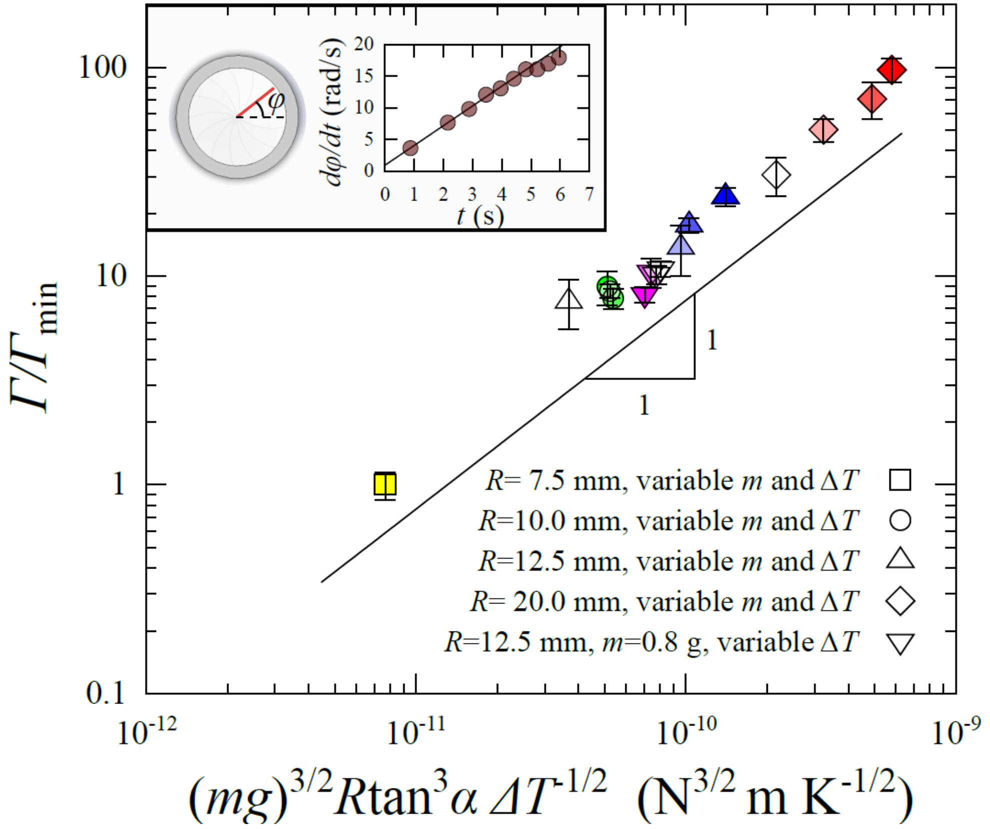
To Spin or Not to Spin?

1. Experiments with changes in (ΔT, R, H) to work out probability of dry ice disk spinning (R=7.5-20 mm, T_h=300-500 C, H=165-229 μm)
2. ca. 60 experiments per mass to determine probability P_S with m_c defined by P_S=0.5



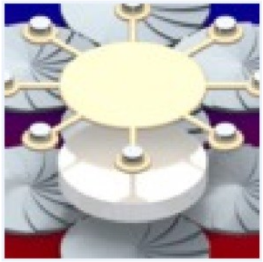
Scaling of Torque

1. Measured angular velocity of dry ice disks ⇒ angular acceleration and hence torque ($\Gamma = I\alpha$) (R=0.75-2 cm, T_h=350-500 C, α=2.25-4.15°, m=0.19-5.13 g)
2. Minimum torque Γ_{min}=0.0109 μN m.

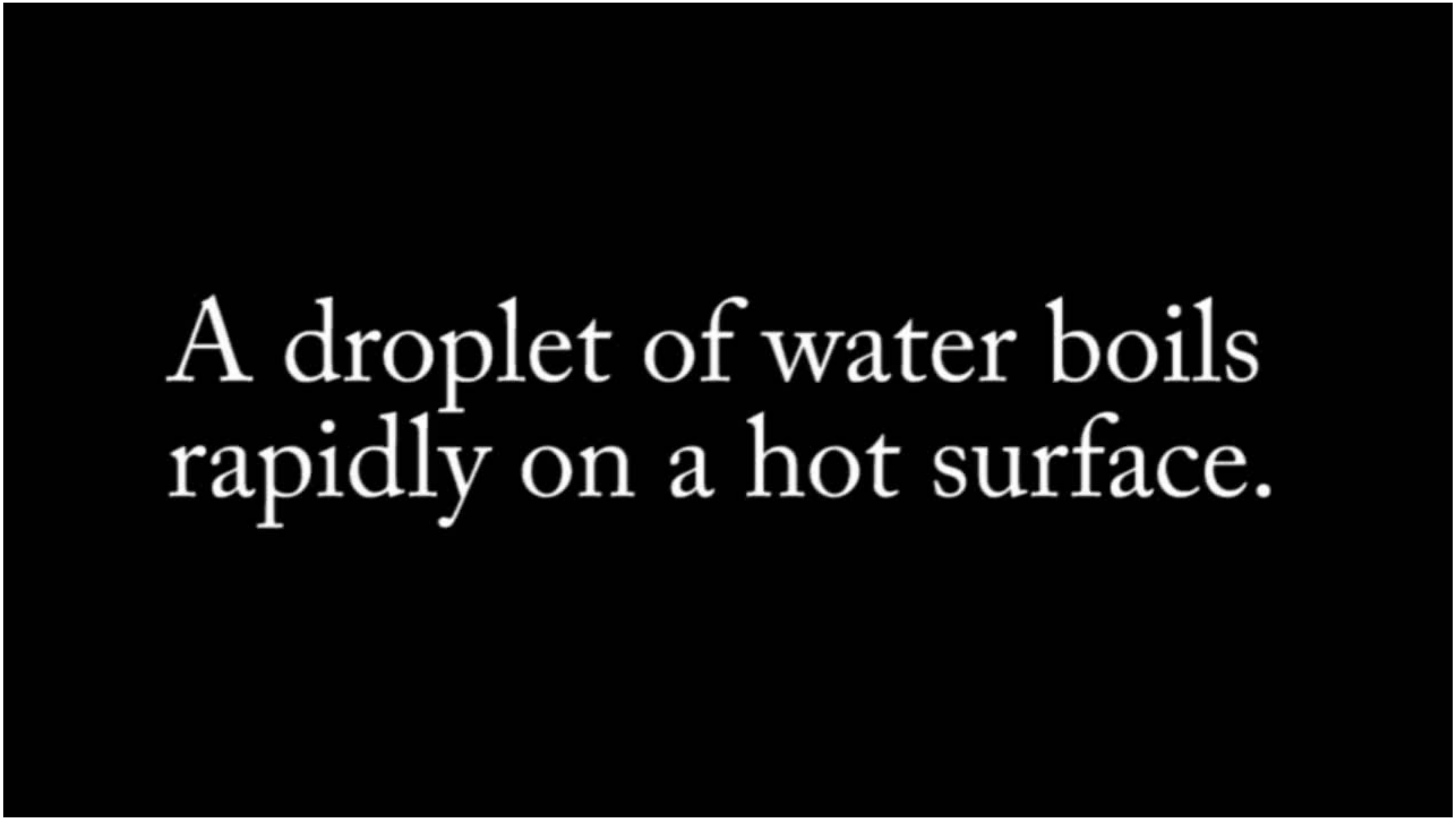


Conversion to Electrical Power

1. 8-lobed commutator with magnets attached to a dry-ice rotor
2. 8-lobe multi-segment induction coil system lowered into proximity to the rotating assembly
3. Generated voltage visualized on an oscilloscope
4. Low phase transition-to-rotational energy efficiency – most energy expended on levitation, but future designs can avoid this



The Leidenfrost Engine Concept



A droplet of water boils
rapidly on a hot surface.

Wells, et al. Nature Commun. (2015) 6 6390.

A Leidenfrost (Heat) Engine

Wells, Ledesma-Aguilar, McHale and Sefiane

***Nature** Communications* (**2015**) 6 art. 6390

Is there life on Mars? Possibly Yes – with Edinburgh energy expert's Leidenfrost engine

EXCLUSIVE By DARA BUTTERFIELD

Professor Khellil Sefiane of Edinburgh University has developed a project with colleagues at Northumbria University that has produced a breakthrough sublimation engine that could one day generate energy on Mars.

The new engine, dubbed the Leidenfrost engine, uses sublimation – the changing of a solid directly into a gas – to drive a generator. The project uses dry ice as its fuel which has created interest in using this technology to power projects on Mars where the substance is common.

Dr Rodrigo Ledesma-Aguilar, co-author on the paper, said: "Carbon dioxide plays a similar role on Mars as water does on Earth. It is a widely available resource which undergoes cyclic phase changes under the natural Martian temperature variations.

"Perhaps future power stations on Mars will exploit such a resource to harvest energy as dry-ice blocks evaporate, or to channel the chemical energy extracted from other carbon-based sources, such as methane gas.

"One thing is certain; our future on other planets depends on our ability to adapt our knowledge to the constraints imposed by strange worlds, and to devise creative ways to exploit natural resources that do not naturally occur here on Earth."

But the breakthrough doesn't just make space-travel and colonisation more sustainable, the unique low friction nature of the engine could have other applications. The concept is could be potentially relevant in challenging situations such as deep drilling, outer space exploration or micro-mechanical manipulation.

Professor Glen McHale, co-author of the paper, said: "This is the starting point of an exciting avenue of research in smart materials engineering. In the future, Leidenfrost-based devices could find applications in wide ranging fields, spanning from frictionless transport to outer space exploration."

View video of the Leidenfrost 'engine' at work

NEWS ARCHIVES

May 18, 2015–May 24, 2015

May 11, 2015–May 17, 2015

May 4, 2015–May 10, 2015

April 27, 2015–May 3, 2015

April 20, 2015–April 26, 2015

NEWS TAGS

oil renewables gas jobs wind safety environment energy shale wind power nuclear fuel poverty wind farm Independence Wave power training fracking coal subsea regulation investment energy efficiency solar fuel prices competition offshore ofgem energy prices biomass skills Fuel bills solar power wave tax wind turbines Energy Academy hydro power community energy Heriot Watt wind farms marine energy North Sea energy policy shale gas Awards

POLICY PLATFORM

Falling oil prices should not undermine investment in green energy

12 May

By FRANS P. de VRIES and ISAAC TABNER When the price of crude oil dropped from $110-barrel in mid-2014 to below $50-barrel by January 2015, there were fears that it would destroy the 'green revolution'. But a look at what's …

Continued

LATEST EVENTS

Edinburgh Energy Club: Scottish Government

May 29

Zero Carbon Energy – The Future

May 27

TODAY'S PAPER » IN SCHOOL

LONDON, March 10, 2015

New energy device may power life on Mars

Vibration Harvester - Piezo Energy Harvester Solutions MFC Harvester, Electronics Wireless
www.smart-material.com
Ads by Google

PTI

PRINT · T T

A new engine for producing energy based on the Leidenfrost effect could be useful in future power stations on Mars

PHOTO: REUTERS

A new type of engine that harvests energy from carbon dioxide could power life on Mars, scientists say.

Researchers propose a new kind of engine for producing energy based on the Leidenfrost effect – a **phenomenon** which happens when a liquid comes into near contact with a surface much hotter than its boiling point.

This effect is commonly seen in the way water appears to skitter across the surface of a hot pan, but it also applies to solid carbon dioxide, commonly known as dry ice.

Blocks of dry ice are able to levitate above hot surfaces protected by a barrier of evaporated gas vapour.

The research pioneered at Northumbria University, Newcastle and Edinburgh University proposes using the vapour created by this effect to power an engine.

This is the first time the Leidenfrost effect has been adapted as a way of harvesting energy.

The technique has exciting implications for working in extreme and alien environments, such as outer space, where it could be used to make long-term exploration and colonisation sustainable by using naturally occurring solid carbon dioxide as a resource rather than a waste product.

Dry ice may not be abundant on Earth, but increasing evidence from NASA's Mars Reconnaissance Orbiter (MRO) suggests it may be a naturally occurring resource on Mars as suggested by the seasonal appearance of gullies on the surface of the red planet.

If utilised in a Leidenfrost-based engine dry ice deposits could provide the means to create future power stations on the surface of Mars.

"Carbon dioxide plays a similar role on Mars as water does on Earth. It is a widely available resource which undergoes cyclic phase changes under the natural Martian temperature variations," said Dr Rodrigo Ledesma-Aguilar, one of the co-authors of the research.

"Perhaps future power stations on Mars will exploit such a resource to harvest energy as dry ice blocks evaporate, or to channel the chemical energy extracted from other carbon-based sources, such as methane gas.

"One thing is certain; our future on other planets depends on our ability to adapt our knowledge to the **constraints** imposed by strange worlds, and to devise creative ways to exploit natural resources that do not naturally occur here on Earth," Ledesma-Aguilar said.

Dr Gary Wells, co-author of the paper, explained the unique properties of an engine based on Leidenfrost effect.

"The working principle of a Leidenfrost-based engine is quite distinct from steam-based heat engines; the high pressure vapour layer creates freely rotating rotors whose energy is converted into power without the need of a bearing, thus conferring the new engine with low friction properties," Wells said. The study was published in the journal Nature Communications.PTI

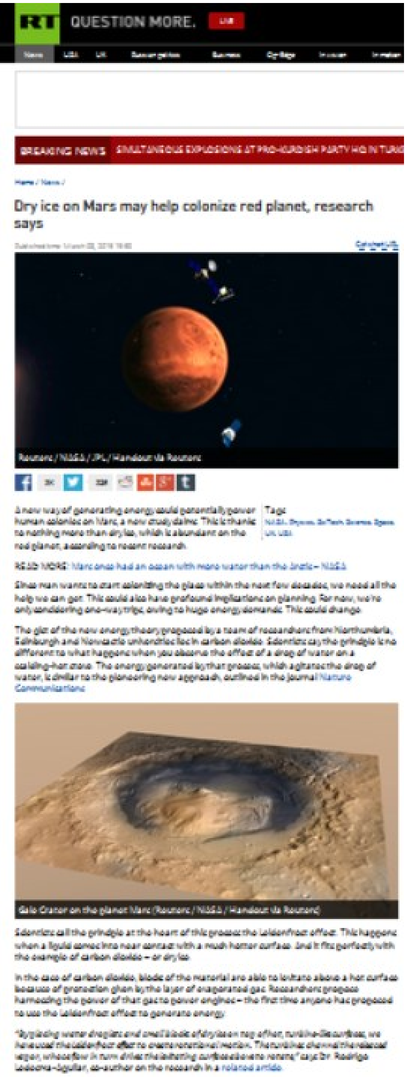
New Energy Harvesting Method Could Use Dry Ice To Power Life On Mars

By Aditya Tejas @Artejas a.tejas@ibtimes.com on March 06 2015 6:51 AM EST

Researchers say the proposed engine would be ideal for Mars missions. Reuters/Ali Jarekji

Researchers at Northumbria University in England say they have invented an innovative technique to harvest energy from solid carbon dioxide. The research, which was published in the journal Nature Communications, makes use of a property of liquids known as the Leidenfrost effect.

The scientists have proposed a new type of engine that would exploit the Leidenfrost effect, which occurs when a liquid comes close to a surface much hotter than its boiling point. This phenomenon is commonly seen when cold water skitters across the surface of a hot pan. The Leidenfrost effect also applies to solid carbon dioxide, better known as dry ice, causing it to hover above hot surfaces due to a barrier of evaporated gas.

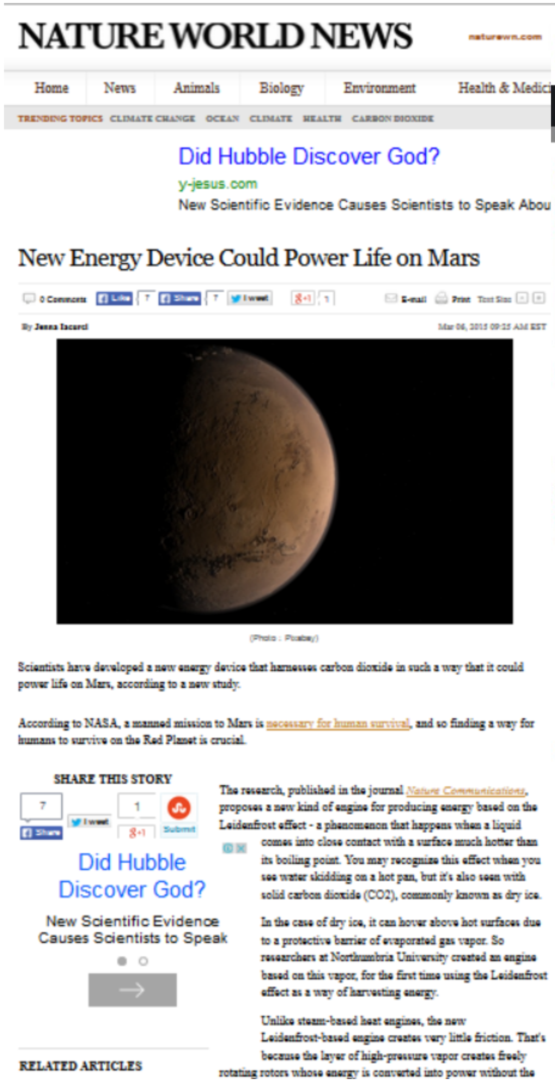


Dry ice on Mars may help colonize red planet, research says

Reuters / NASA / JPL / Handout via Reuters

Gale Crater on the planet Mars (Reuters / NASA / Handout via Reuters)

Researchers proposes new type of engine that harvests energy from carbon dioxide and could power life on Mars



New Energy Device Could Power Life on Mars

By Jenna Iacurci

Mar 06, 2015 09:25 AM EST

(Photo : Pixabay)

Scientists have developed a new energy device that harnesses carbon dioxide in such a way that it could power life on Mars, according to a new study.

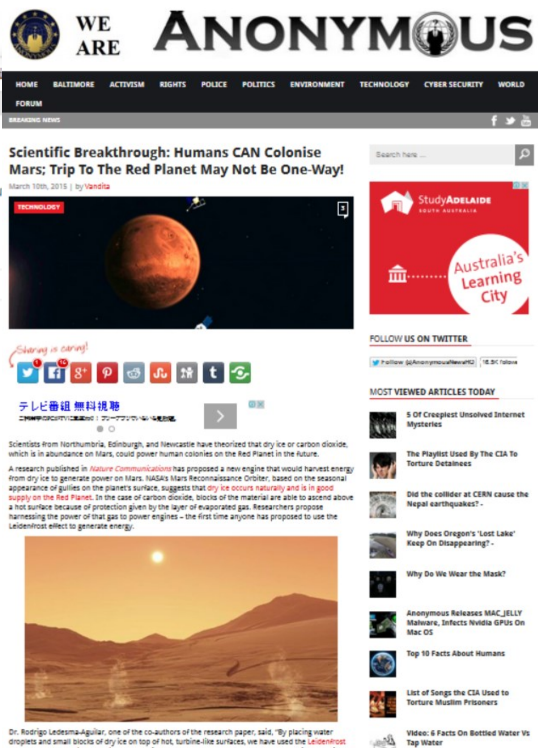
According to NASA, a manned mission to Mars is necessary for human survival, and so finding a way for humans to survive on the Red Planet is crucial.

RELATED ARTICLES

The research, published in the journal *Nature Communications*, proposes a new kind of engine for producing energy based on the Leidenfrost effect - a phenomenon that happens when a liquid comes into close contact with a surface much hotter than its boiling point. You may recognize this effect when you see water skidding on a hot pan, but it's also seen with solid carbon dioxide (CO2), commonly known as dry ice.

In the case of dry ice, it can hover above hot surfaces due to a protective barrier of evaporated gas vapor. So researchers at Northumbria University created an engine based on this vapor, for the first time using the Leidenfrost effect as a way of harvesting energy.

Unlike steam-based heat engines, the new Leidenfrost-based engine creates very little friction. That's because the layer of high-pressure vapor creates freely rotating rotors whose energy is converted into power without the



Scientific Breakthrough: Humans CAN Colonise Mars; Trip To The Red Planet May Not Be One-Way!

March 10th, 2015 | by Vandita

Scientists from Northumbria, Edinburgh, and Newcastle have theorized that dry ice or carbon dioxide, which is in abundance on Mars, could power human colonies on the Red Planet in the future.

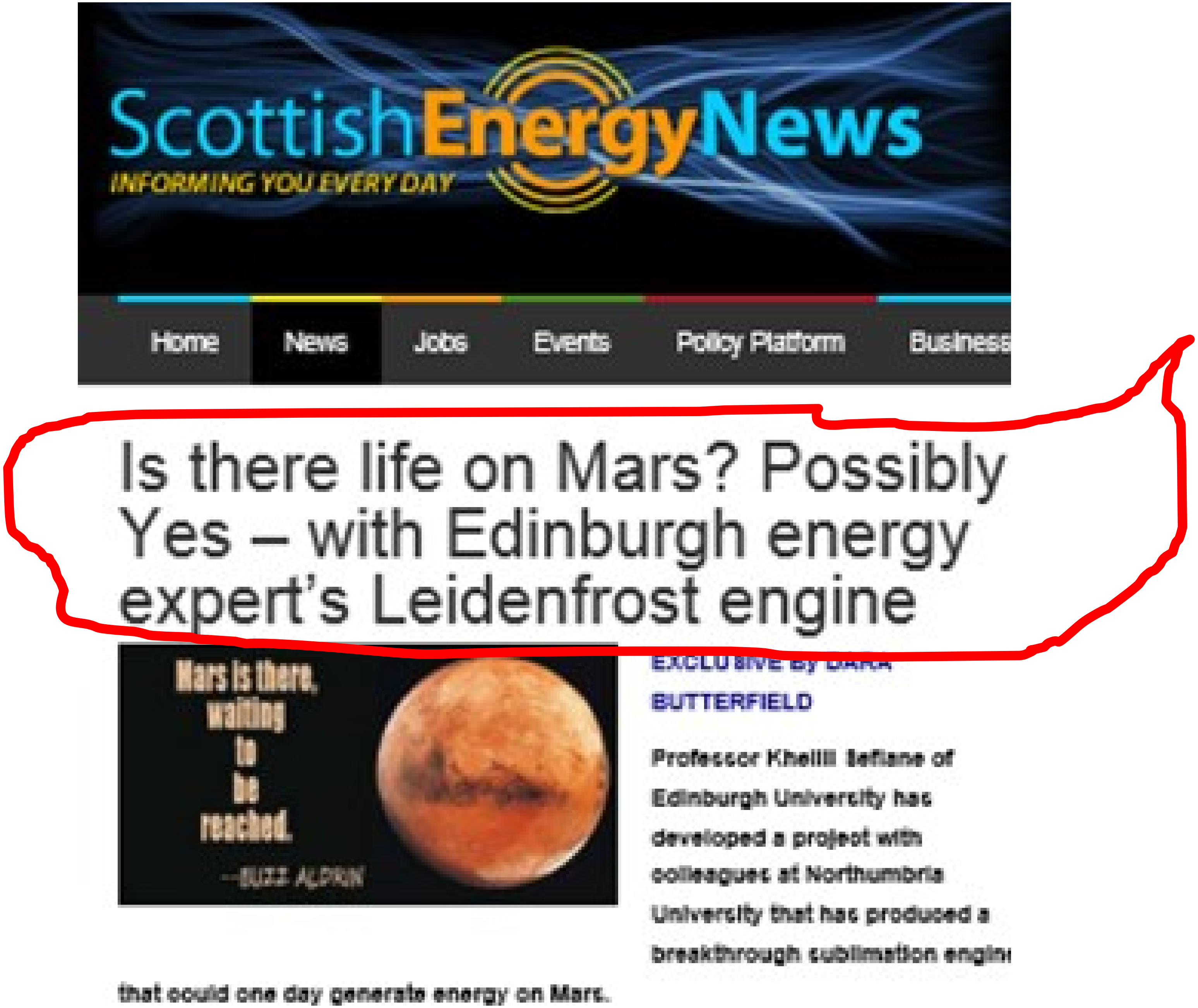
A research published in *Nature Communications* has proposed a new engine that would harvest energy from dry ice to generate power on Mars. NASA's Mars Reconnaissance Orbiter, based on the seasonal appearance of gullies on the planet's surface, suggests that dry ice occurs naturally and is in good supply on the Red Planet. In the case of carbon dioxide, blocks of the material are able to ascend above a hot surface because of protection given by the layer of evaporated gas. Researchers propose harnessing the power of that gas to power engines – the first time anyone has proposed to use the Leidenfrost effect to generate energy.

Dr. Rodrigo Ledesma-Aguilar, one of the co-authors of the research paper, said, "By placing water droplets and small blocks of dry ice on top of hot, turbine-like surfaces, we have used the Leidenfrost

FOLLOW US ON TWITTER

MOST VIEWED ARTICLES TODAY

- 5 Of Creepiest Unsolved Internet Mysteries
- The Playlist Used By The CIA To Torture Detainees
- Did the collider at CERN cause the Nepal earthquakes? -
- Why Does Oregon's 'Lost Lake' Keep On Disappearing? -
- Why Do We Wear the Mask?
- Anonymous Releases MAC_JELLY Malware, Infects Nvidia GPUs On Mac OS
- Top 10 Facts About Humans
- List of Songs the CIA Used to Torture Muslim Prisoners
- Video: 6 Facts On Bottled Water Vs Tap Water



ScottishEnergyNews

INFORMING YOU EVERY DAY

Is there life on Mars? Possibly Yes – with Edinburgh energy expert's Leidenfrost engine

EXCLUSIVE by DARA BUTTERFIELD

Professor Khellil Sefiane of Edinburgh University has developed a project with colleagues at Northumbria University that has produced a breakthrough sublimation engin that could one day generate energy on Mars.

Thank you.

Any questions, welcome.