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Temperature measurements and thermography at the palmar surface of the human hand

The Infrared Radiation Dilemma 1800-1840

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The Infrared Radiation Dilemma 1800-1840

Francis Ring

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SUMMARY

William Herschel's important discovery of thermal radiation was met with praise by England's leading Scientist Sir Joseph Banks. It was, however, heavily criticized elsewhere, due to the lack of understanding about the nature and properties of light that he had been studying. Efforts were made to reproduce Herschel's experiment, which proved successful. However, a number of other scientists contributed to the expanding knowledge over many years. Today we have proven evidence of the electromagnetic spectrum and the place of infrared radiation within that spectrum. Neither the terminology nor the physics of light as a form of radiation had been established in 1800.

KEYWORDS: History of physics, infrared, radiation, theory of light

DAS DILEMMA DER INFRAROTSTRAHLUNG IM ZEITRAUM 1800-1840

Der führende Wissenschaftler Englands, Sir Joseph Banks, begegnete William Herschels bedeutender Entdeckung der Wärmestrahlung mit Lob. Herschel wurde aber von Anderen heftig kritisiert, da die Natur und Eigenschaften des Lichts, die er studiert hatte, nicht ausreichend verstanden wurden. Es wurden erfolgreiche Anstrengungen unternommen, Herschels Experiment zu reproduzieren. Allerdings trugen eine Reihe von anderen Wissenschaftlern zu dem wachsenden Wissen über viele Jahre bei. Heutzutage ist die Existenz eines elektromagnetischen Spektrums und der Platz der Infrarot-Strahlung innerhalb dieses Spektrums bewiesen. Hingegen waren im Jahre 1800 weder die Terminologie noch die Physik von Licht als Strahlung etabliert.

SCHLÜSSELWÖRTER: Geschichte der Physik, Infrarot, Strahlung, Licht-Theorie

Thermology international 2016, 26(4) 101-106

Introduction

The foundation for the infrared part of the electromagnetic spectrum was laid by two members of the same family. William Herschel the astronomer was an outstanding telescope builder in his day. In studying the possible effect of different colours on the eye, he found the heating effect beyond the visible red, which he called dark heat, now known as infrared radiation.

Figure 1.
Herschel's experiment that revealed heat beyond the visible red of the spectrum

His son John after his father's death in 1822, carried out experiments on natural sunlight and successfully created a thermal image in 1840 which he called a thermogram.

Table 1 Properties of light and heat

Light	Heat
Sensation occasioned by rays from luminous bodies, with power to illuminate (and make them appear various colours)	Sensation occasioned by rays emanating from candent substances which heat bodies
Subject to laws of reflection	Subject to laws of reflection
Refraction	Refraction
Different refrangibilities	Different refrangibilities
Can be stopped by diaphanous bodies	Can be stopped by diaphanous bodies
Scattered by rough surfaces	Scattered by rough surfaces
Supposed to have heating powers, but this remains to be examined	Supposed to have the power to illuminate objects, but this remains to be examined

Figure 2
Table reprinted from Ref 1 in which Herschel compares properties of ligh and heat

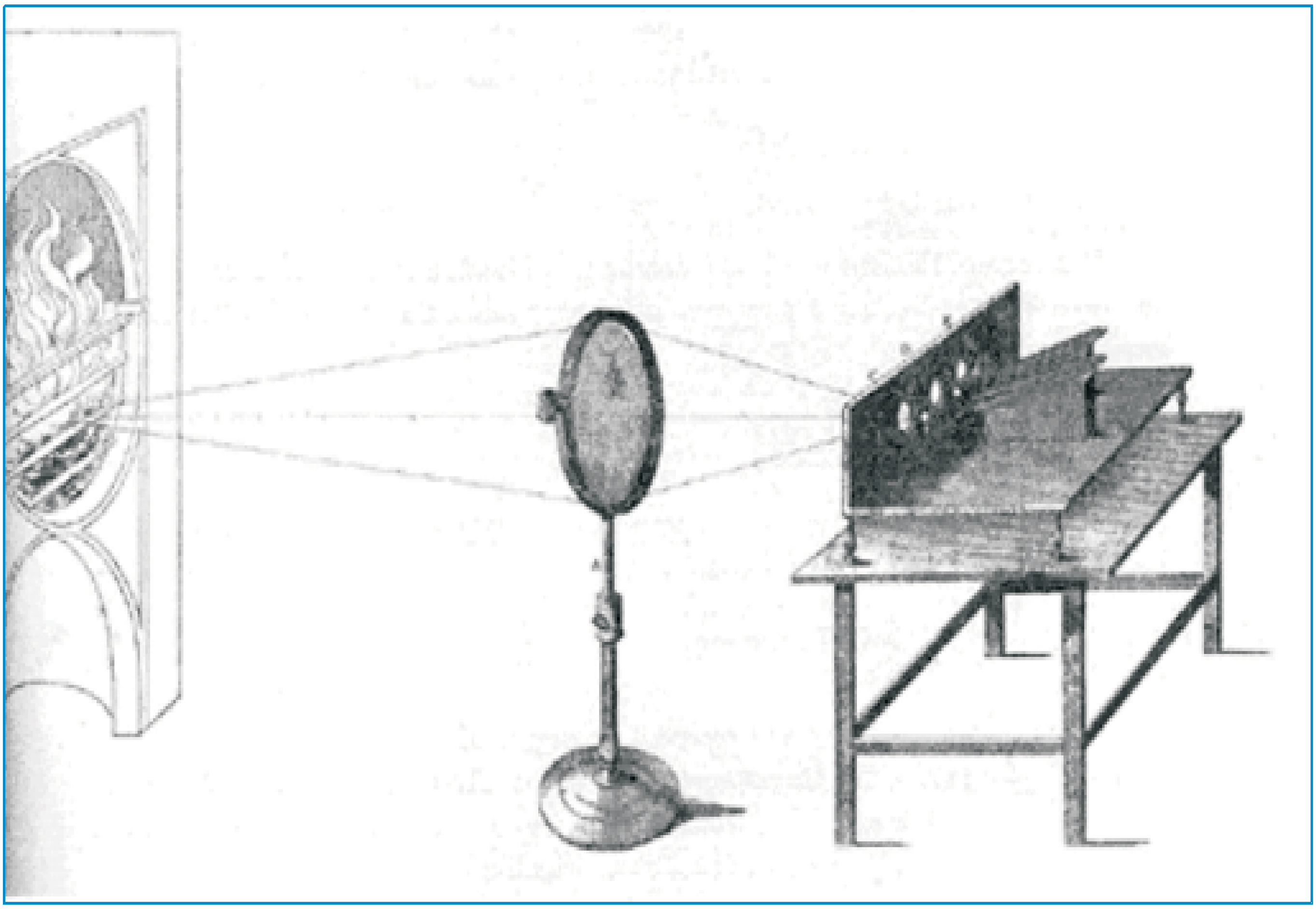


Figure 2B
Set up of William Herschels experiment to show that heat can be focussed through a "burning" lens through the small holes in the wooden screen to concentrate the heat from the fire on to the thermometer bulb [1]

William Herschel's series of experiments were quite extensive in that he made further studies into the nature of this formerly unknown heat, showing similarities and dissimilarities with visible light.

These significant findings were reported to the Royal Society in London in March 1840 and are published in detail in the Philosophical Transactions of that Society[1,2,3]. This was the leading British scientific Journal that was highly regarded by the scientific world in the 18th century.

Experiments on the solar, and on the terrestrial rays that occasion heat; with a comparative view of the laws to which light and heat, or rather the rays which occasion them, are subject, in order to determine whether they are the same, or different [Part 1]. Over 100 pages of the journal were given to this major discovery of Herschel.

The then President of the Royal Society, Sir Joseph Banks was immediately impressed with the importance of this new discovery. He was reported to have said= "..as highly as I prized the discovery of the new planet (Uranus 1781) I consider the separation of heat from light as a discovery pregnant with more important additions to science"

Herschel had reported a number of important findings for the first time. Not only was there evidence of energy that was not visible with the human eye, but that this new dark heat could be reflected and refracted like visible light.

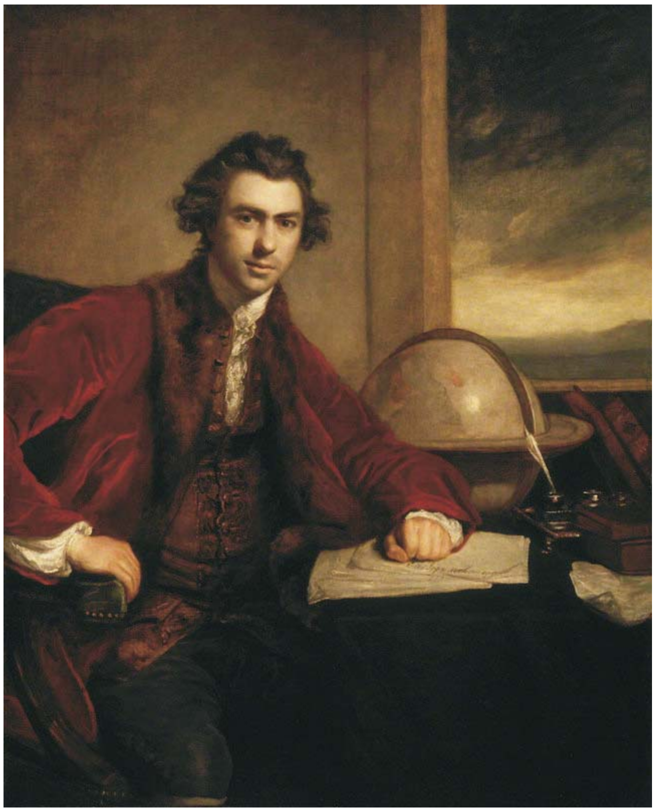
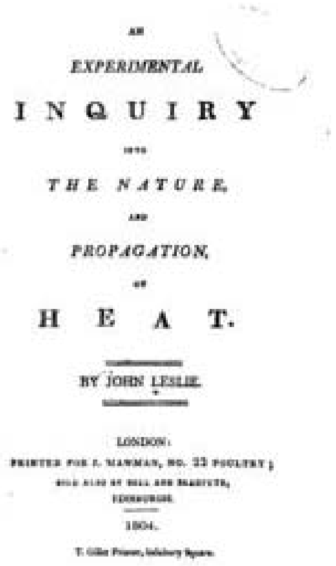


Figure 3
Sir Joseph Banks, President of The Royal Society, London

Figure 4
John Leslie, physicist 1766-1832



AN
EXPERIMENTAL
INQUIRY
INTO
THE NATURE,
AND
PROPAGATION,
OF
HEAT.

BY JOHN LESLIE.

LONDON:
PRINTED FOR J. MAWMAN, NO. 22 POULTRY;
1804.

Figure 5
The title of John Leslie's work " An experimental inquiry on the nature and propagation of heat"

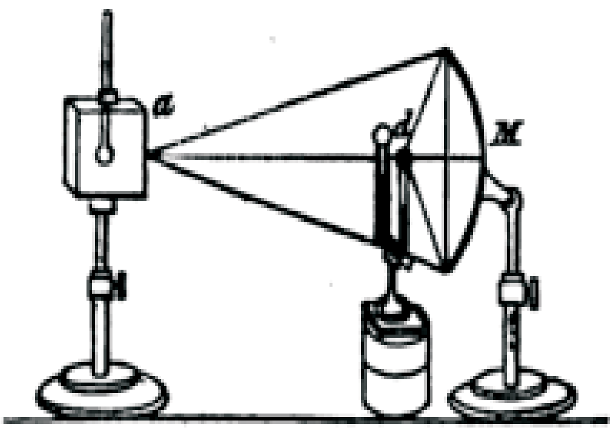


Figure.6
From the above publication, diagram of the Leslie cube

This acclaim from the most senior figure at The Royal Society, was not however, entirely supported. An experienced physicist from Scotland John Leslie had been conducting experiments on "radiant heat" for nearly 10 years in 1800 when William Herschel's papers were announced. He found the idea that rays from the sun could be invisible was a contradiction!

Leslie published in a widely read newspaper that acceptance of Herschel's invisible rays would retard the progress of science and that it was unfounded and inaccurate. These remarks were based on a mistaken understanding that energy could fall on the human eye but be unseen. He had in fact been carrying out studies of his own on radiant heat for ten years and his major work was not published until 1804. This was titled "An experimental enquiry into the nature and propagation of heat".

This criticism must have been a harsh rebuke to Herschel, though now highly regarded for his work in astronomy was still in some respects an amateur scientist. He did not respond to this public rebuke but others in the London circle of scientists realised that this matter could not be ignored.

The response however came from a higher source. Professor Thomas Young FRS, Head of Natural Philosophy at The Royal Institution in London asked Sir Henry Englefield FRS to repeat Herschel's experiment in early 1801. In his experiment he used an equilateral prism and a lens of 22 inches focal length. He isolated the colours with a slot cut into card, to avoid any heat getting through by reflection. This was a way to repeat Herschel's experiment but with

Figure 7
Sir Henry Englefield FRS who verified Herschel's experiment

Figure 8
Thomas Young, who proposed the wave theory of light in 1801

different materials. Two independent witnesses were able to verify that the experiment did in fact confirm that therewas heat found beyond the visible red.

One year later another scientist Sir Humphrey Davey repeated the experiment and further confirmed the presence of Herschel's dark heat. As a result of these independent tests Herschel had been vindicated, although John Leslie had published further complaints [4,5].

There were other milestones in the slow but steady clarification of the nature of heat and light.

In the early nineteenth century there was no knowledge of the electromagnetic spectrum as we know it today. Much was yet to be discovered. However, Thomas Young in November 1801 gave his famous lecture on the theory of Light and Colours, which advocated the wave theory of Light.. He brought more understanding into the concept of invisible rays.

Young considered that it was highly probable that light differs from heat only in the frequency of the undulations or vibrations. He suggested that the human eye would only have a limited sensitivity to different frequencies. He further supported Herschel in that transmission characteristics of some materials may differ markedly between heat and light. William Herschel died in 1738, before John Herschel, William's only son carried out an experiment in 1840 to attempt to record an image of the effect of his father's invisible rays from natural sunlight.

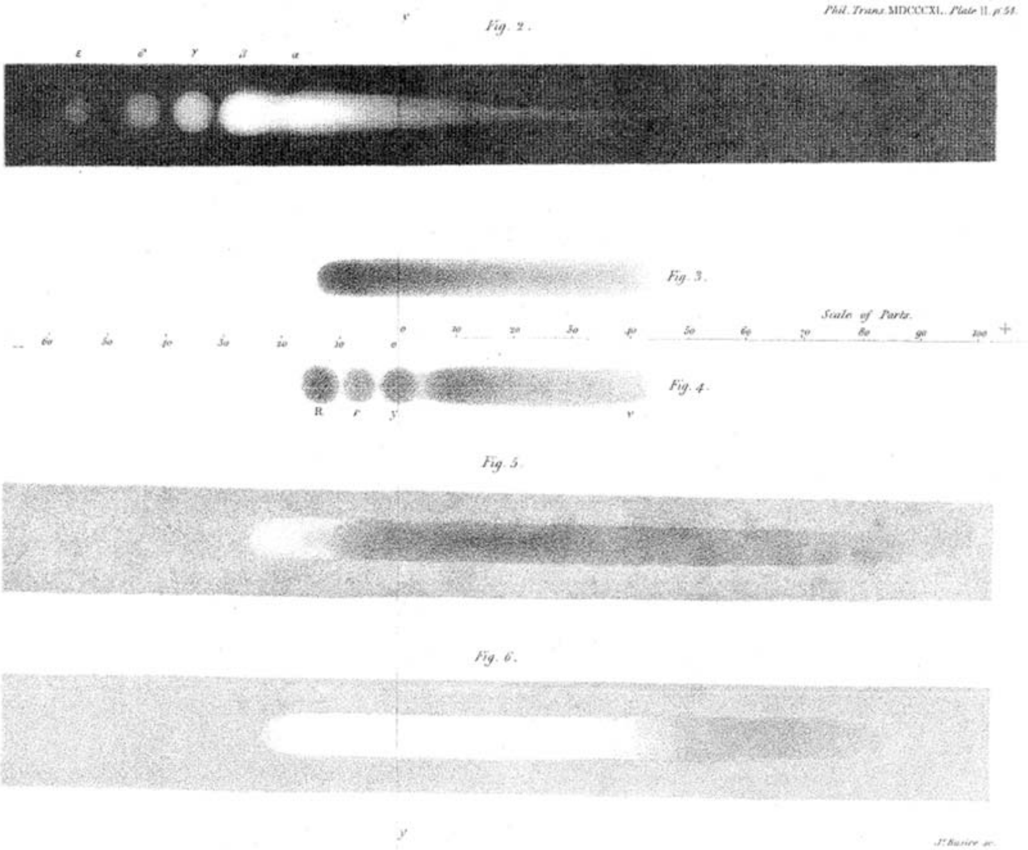


Figure 9
The Solar thermogram made by John Herschel in 1840

Figure 10
Macedonio Melloni 1798 - 1854

Figure 11
The large Fresnel lens used by Melloni

1840 to attempt to record an image of the effect of his father's invisible rays from natural sunlight.

Using a primitive form of evaporography he focussed sunlight on to a sheet of glass coated with a suspension of soot in dilute alcohol. Over the period of a day he had a scattering of the carbon particles by the heat, which was reduced or absent during cloud cover of the sun. This paper was published in the Philosophical Transactions in which John Herschel named his image a thermogram.

By this time the criticism of Leslie had been silenced and we today have the benefit of many other researchers who have brought us to the point of modern day thermal imaging.

As scientific research continued interesting findings came from Italy. MacedonioMelloni1798 - 1854, Director of the Meteorological Observatory in Naples obtained the large Fresnel lens. He focussed moon light on to a thermos-multiplier, and the needle swung immediately. For centuries moonlight was considered to be "cold". Francis Bacon had described it as a negative instance of heat. Pictet had also focussed moonlight but detected no heat. However, his instrument did show a cooling effect. He repeated many times until finally produced a repeatable heating effect. Melloni's experiments were important in that they identified radiant heat as long wavelength light.

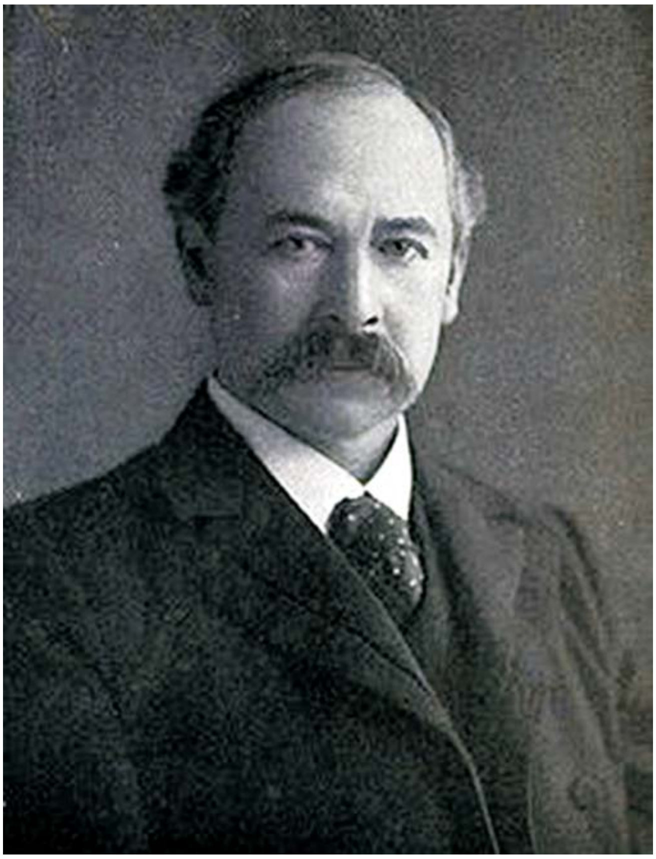
Samuel Langley in 1889 said that Melloni persevered because the principle of the identity of radiant light with heat assured him that with light there must be heat! Melloni was named the "Newton of heat". Melloni's importance was the identification of radiant heat as long wavelength light.

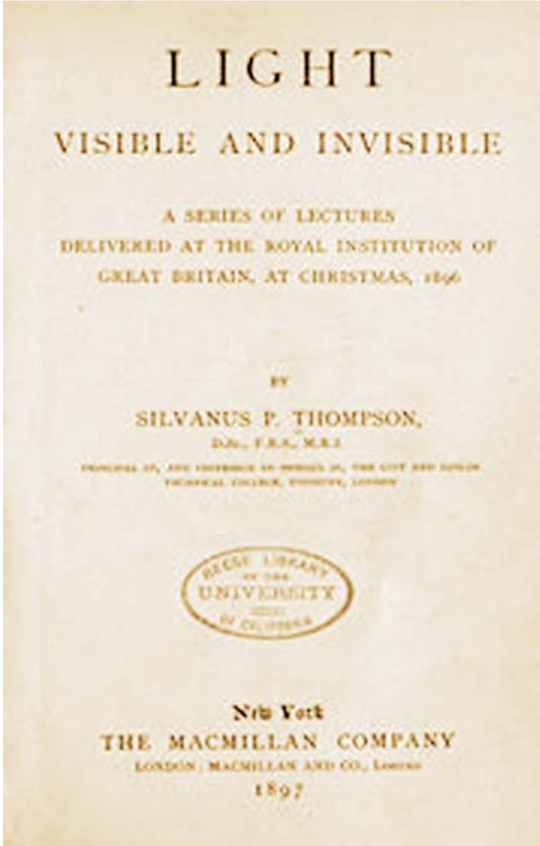
His experiments in the 1830's went against the concept that obscure radiant heat was invisible light, and turned many away from the idea that there could be such a phenomenon as non-illuminating light.

Herschel had studied sunlight through filters and thought that different colours carried different amounts of heat. In his 1800 paper he reported " the full red falls short of the maximum of heat, which perhaps lies beyond visible refraction. In this case, radiant heat will at least partly or chiefly consist of invisible light, that is to say of rays from the sun that have such a momentum as to be unfit for vision. He therefore concluded that heat and light seem to be unconnected".

Herschel had therefore discovered isolatable caloric rays in sunlight. This started a powerful transition of scepticism about the identity of heat rays and of light rays. The pluralistic theory of radiation was formed with a distinct type of radiation for each type of radiative effect, heating, illumination, chemical reaction etc. Before long this theory was rejected in favour of the unified theory of radiation. Malloni changed over to this in the early 1840's.

Others supported this theory and Silvanus Thompson in 1896 in his publication" Light, visible and invisible" concluded this view.




LIGHT

VISIBLE AND INVISIBLE

A SERIES OF LECTURES
DELIVERED AT THE ROYAL INSTITUTION OF
GREAT BRITAIN, AT CHRISTMAS, 1896

BY

SILVANUS P. THOMPSON,

New York
THE MACMILLAN COMPANY
1897

Figure12
Silvanus Thompson and his 1896 publication on Light visible and Invisible.

This is clearly summarised in these words " The chief physical effect produced by long infrared waves is that of warming things that they fall on The invisible light of this kind possesses (except visibility) all of the physical properties of light. If we can reflect it and refract it, disperse it diffract it and polaraise it them w are logically compelled to admit that it is really light. "

Herschel's experiments on radiant heat show how he understood the role of experiment and how he handled potential difficulties in measurement. He believed that experiments could answer essential questions about nature and was willing to change his mind in light of evidence. Potential problems with data did not shake his confidence in the results of his experiments.

Herschel's critic, Leslie, had even less patience with experimental results that did not fit his theory. His harsh condemnations of Herschel's work could not be empirically substantiated, but they pointed to problems of which Herschel was aware.

Although the theories of both men about radiant heat have subsequently been abandoned, attempts to address their concerns and differences contributed to the development of the electromagnetic spectrum. The unification of radiant heat and light through the spectrum came about after better instruments made it possible to account for the rival claims of earlier experimenters.

Today modern infrared imaging systems have had a dramatic impact on medicine, science engineering and astronomy. It was to take another 100 years from John Herschel's infrared thermogram before a successful means of harnessing thermal imaging could be realised.

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Temperature measurements and thermography of the palmar surface of the human hand - An overview

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Medical Imaging Research Unit, University of South Wales, Treforest Campus, Pontypridd, UK

SUMMARY

This overview summarises the literature on temperature measurements or thermal imaging of the palms. In some publications, the hand was regarded as one of many anatomical regions in which reference temperatures had to be obtained. Sufficiently large thermal images of the hands were found in only two reference studies, in which the hand had filled 60-80% of the thermal image. Some data were extracted from healthy control subjects in studies that had investigated hand temperature in patients with rheumatoid arthritis, diabetes type 2 or cardiovascular risk factors. Only 1 article reported agreement between palmar and dorsal hand temperatures measured at single spot with an infrared radiometer. Temperature measurement at the palmar side of the hand with contact thermometers or infrared technology are routinely used for monitoring of sympathectomy, which is a treatment option for hyperhidrosis. Heterogeneity in study design and conditions for measurement did not allow data pooling. 75% of articles that compared dorsal and palmar hand temperatures reported a difference less than 0.2°C. Dissection of sympathetic nerve fibres is followed by an increase in hand temperature by approximately 3 C° within 35 min. A large change in hand temperature up to 9°C was observed by infrared thermography 2 to 7 days after surgery. Standards and guidelines for thermal imaging and for the generation of reference values must be followed strictly, to enable a systematic analysis of pooled reference values for palm temperatures in the future.

KEY WORDS: **palmar hand temperature, reference value, monitoring, sympathectomy**

TEMPERATURMESSUNGEN UND THERMOGRAFIE AN DER MENSCHLICHEN HANDFLÄCHE: EINE ÜBERSICHT

Diese Übersicht stellt die Literatur zu Temperaturmessung oder Thermografie der Handflächen zusammen. In einigen Veröffentlichungen wurde die Hand als eine von vielen anatomischen Regionen verstanden, in denen Referenz-Temperaturen erstellt werden mussten. Ausreichend große Wärmebilder der Hände fanden sich nur zwei Referenzstudien, in denen die Hand 60-80 % des Wärmebildes ausgefüllt hatte. Einige Daten wurden von gesunden Kontrollpersonen extrahiert in Studien, in denen die Hand-Temperatur bei Patienten mit rheumatoider Arthritis, Diabetes Typ 2 oder Herz-Kreislauf-Risikofaktoren untersucht worden war. Nur 1 Artikel berichtete die Übereinstimmung zwischen der Temperatur der Handfläche und des Handrückens, die an einer einzigen Stelle mit einem Infrarot-Radiometer gemessen worden war. Temperaturmessung an der Palmarseite der Hand mit Kontakt-Thermometer oder Infrarot-Technologie werden routinemäßig zur Überwachung der Sympathektomie verwendet, die ist eine Behandlungsoption bei Hyperhidrose darstellt. Heterogenität im Studiendesign und den Messbedingungen erlaubte eine Zusammenfassung der Daten nicht. 75 % der Artikel, welche Handflächen- und Handrückentemperaturen verglichen, berichteten einen Unterschied von weniger als 0,2 °C. Die Durchtrennung der sympathischen Nervenfasern wird innerhalb von 35 min von einem Handtemperaturanstieg von etwa 3 C° gefolgt. Eine große Änderung in der Handtemperatur von bis zu 9 °C wurden durch Infrarot-Thermografie erst 2 bis 7 Tage nach der Operation beobachtet. Normen und Richtlinien für Thermografie und zur Erzeugung von Referenzwerte sind streng, einzuhalten, um in der Zukunft eine systematische Analyse von gepoolten Referenzwerten für Handflächen-Temperaturen zu ermöglichen.

SCHLÜSSELWÖRTER: **Handflächentemperatur, Referenzwert, Überwachung, Sympathektomie**

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Introduction

Infrared thermal imaging of the hands is one of the earliest application of thermography. Main motivation for the use of thermography was the ability of the technique to show the inflammatory activity in patients suffering from rheumatoid arthritis [1-3]. Case reports describing peripheral vascular diseases with manifestation on the hands were already published in 1964 [4,5] and reports about thermographic research in Raynaud´s disease and vibration induced fingers followed soon. The later disorders present typically with temperature changes on the hands [6-8].

In most studies the dorsal surface of the hand is captured by a thermal imager. However, temperature measurements in vibration induced fingers is typically performed with thermistors fixed to the volar side of fingers and or to the palm [9]. Palm temperature was used for the assessment of thermal comfort of elderly people in their homes [10,11]. Temperature measurements at the palmar hand is an established method for intraoperative monitoring of endoscopic superior thoracic sympathectomy as a treatment option for palmar hyperhidrosis [12].

Recently, the question arose which side of the hand is the most appropriate for infrared thermal imaging based temperature measurements. This paper will review the medical fields where temperature measurement at the hands are either established or its clinical value have been investigated and whether the palmar or the dorsal side are preferenced for temperature measurements.

Method

A pilot literature search was performed in the databases Web of Science (WoS) and Scopus using the search terms "palmar" AND "hand temperature" AND "humans". The period of publication was between 1964 and July 2016.The primary intention of this search was to identify the medical conditions where temperature measurement of the palmar skin temperature is used.

Unfortunately, the number of hits was very low: 5 hits in WoS and 22 in Scopus. Therefore, the search was repeated with the key words “hand temperature” AND “humans”, obtaining 181 hits in WoS and 320 in Scopus.

The search tool in WoS allows a simple search only in the field “topic”, but Scopus permits a much wider search including not just the fields title, author, source and abstracts, but also references. This difference in accessed field may be main reason for the difference in the number of hits in used databases. References available in the authors´ literature collection completed the database of this review.

Table 1
Indications for hand temperature measurements

- Reference values from healthy subjects [
- Rheumatoid arthritis
- Psoriasis arthritis
- Hand osteoarthritis
- Hand CRPS
- Peripheral vasculuar disease
- Lymphedema
- Raynaud’s phenomenon
- Vibration induced white fingers
- Cold hypersensitivity
- Thermal comfort
- Cold injuries
- Carpal tunnel syndrome
- Thoracic outlet syndrome
- Hyperhydrosis
- Monitoring surgery for hyperhydrosis
- Thermoregulation in physical exercise
- Thermoregulation due to thermal stimuli
- Haemorhagic shock
- Collaps
- Psychological stress
- Diabetes mellitus
- Cardiovascular risk factors
- Biofeedback treatment
- Drug effects

First step was to identify the medical conditions in which hand temperature measurements have been of interest. Titles and if available abstracts of identified papers were read and obviousley non adequate publications were excluded. As far as possible, full versions of the publications were obtained.

For the final review, only papers reporting temperature values for the palmar or both sides of the hands were included. These temperature readings were collected and presented in tables in combination with the site of temperature measurement at the hand, room temperature, acclimation time and used instrumentation. Personal characteristics such as gender and age, health condition and the sample size of studied subjects complete these tables.

Results

A wide range of indications for measuring hand temperature measurements was found in a total of 160 papers comprising review papers, controlled studies, observational studies and case reports (table 1). These papers reported temperature measurements either as a complementary method for assisting medical diagnosis or as a method for monitoring a health condition. A large proportion of publications tried to establish reference values for local skin temperature of defined anatomical regions including the hands.

Hand temperature wasalso used as operant feedback signal in the treatment of patients suffering from cold fingers induced by psychological disturbances.

The following data analysis is based on 18 papers[13-31] that reported either reference values for skin temperature, agreement between palmar and dorsal temperatures or inter- ventions where palmar hand of finger temperatures have been used for monitoring.

Conditions of temperature measurements

Equipment

All 18 studies provided a name of the device used for temperature measurement. In 12 studies, temperature measurement was based on infrared thermal imaging [13-24, 26], 2 studies used infrared thermometers [25,27] and the remaining 4 applied thermistors applied to to the skin for temperature measurements [28-31]. However, the camera type could not be unequivocally identified in 3 cases[13, 14, because it was impossible to match the reported camera name with the camera designation provided by the manufacturer. For example, the Fluke product list contains a “Ti25 (and Ti10”[32] or a “TIR125 among the Ti(R)100 series” [33], but not a “TIR-25” as reported by Marins et al. [13,14]. The Flir 7000 series comprises 4 different camera types either equipped with a mid- or long-waveband detector [34], but none is labelled SC7000 as indicated by Gatt et al. [19]. The Avionics TVS- 2000 named by Niu et al. [20] might be TVS-200EX [35]or TVS-200IS [36].

Type of infrared camera

8 different types of infrared camera were reported, 6 of them are equipped with a focal plane array, and 2 use a scan-

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Type of infrared camera

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Table 2
Reference temperature of the palm or dorsum of the hand: healthy subjects or non-symptomatic controls
*Temperatures have been estimated from the diagram provided NA=information not available SD=standard deviation CI= confidence interval
QR= quick temperature recovery SQ= slow temperature recovery

Author	Temperature measurements					Participants		Temperature findings (°C)			
	equipment	Room temperature (C°)	Acclimation Time (min)	view	Region of interest	gender	Age (years)	palmar		dorsal	
								right	left	right	left
Marins et al	Flúke TIR-25	19.0 ± 0.3	20	Upper half body	Rectangular palmar and dorsal hand	18 men	22.3 ± 3.1	30.3 ± 2.0	30.5 ± 2.0	29.9 ± 1.4	29.5 ± 1.4
						26 women	21.7 ± 2.5	27.8 ± 2.1	28.0 ± 2.3	27.7± 1.7*	27.3± 1.7*
Marins et al	Flúke TIR-25	21 ± 0.3	15	Upper half body	Rectangular palmar and dorsal hand	103 men	21.3 ± 2.2	28.2 ± 2.6	28.34±2.6	28.06±2.1	28.00±2.1
						117 women	21.9 ± 2.2	28.40 ± 2.2	28.6±2.2	28.4±1.8	28.2±1.8
Chudecka & Lubkowska	ThermaCAM SC500 (FLIR)	25	20	total body	Area inside the outline of hand	100 men	20–23	31.9 ± 0.2		31.8 ± 0.3	
						100 women	20–23	31.9 ± 0.3		31.8 ± 0.3	
Chudecka et al	ThermaCAM SC500 (FLIR)	25	20	total body	Area inside the outline of hand	20 women BMI $>30 kg/m^2$	20–25	31.7 ± 0.3		31.5 ± 0.2	
						20 women BMI $<25 kg/m^2$	21–23	31.9 ± 0.8		31.7 ± 0.8	
Kolosovas- Machuca & Gonzales	FlexCam-S	22 ± 1	15	total body	Spot, central palm, central dorsum	25 children 15 boys,, 10 girls	2 -15 (mean 7.8)	32.5 ± 0.8	32.7 ± 0.6	32.3 ± 1.1	32.4 ± 1
Snekhalatha et al	ThermaCAM T400 (FLIR)	20	15	right hand, anterior view	Rectangular palmar hand	15 healthy men	Mean 45.5±11.8	34.43±0.2			
Gatt et al	FLIR Model SC 7000;	22.6± 0.39	20	right hand, anterior view	3 circles at MCP1 MCP2&3 MCP4&5	63 subjects (24 men,39 women)	Mean 36 ± 12.24	MCP1* MCP2/3* MCP4/5*	29.8 ±2.0 29.3 ± 2.3 29.0 ± 2.2	MCP1* MCP2/3* MCP4/5*	29.7 ±2.0 29.1 ± 2.3 29.0 ± 2.2
Niu et al	Avionics TVS-2000	21 ± 1	20	total body	Polygon Wrist to MCP-joints	57 subjects (35 men, 22 women)	24 - 80	31.3 ± 1.4 (29.7 to 32.6)		30.3 ± 1.0 (26.7 to 32.0)	
Zhu & Xin	AGEMA Thermovision 470 Pro	25	30	NA	NA	223 subjects 138 men, 85 women	42.5 ± 8.8	32.7 ± 1.18	32.6 ± 1.23	31.8 ± 1.2	31.7 ± 1.2
Leijon-Sundqvist	FLIR® A320	23 ± 1	30	hand, anterior view	4 polygons at the palm Area inside the outline of hand	232 hands (67 men) repeated imaging in 50 subjects QR: 67 SR:153	23 ± 3	Palm QR: 30.4±1.4 Palm SR: 28.0±1.8 Total hand QR: 29.7±1.4 Total hand SR: 25.5±2.6			
Sivanandam et al	ThermaCam FLIR T400	23	15	forearm with hand	Rectangular at the palm	32 subjects	40 ± 12	33.64 ± 1.42			
Thiruvengadam	ThermaCam FLIR T400	20	15	forearm with hand	Rectangular at the palm	21 subjects 12 men, 9 women	53± 10.3	34.1±0.7 (32.4-35.8)	34.0±0.6 (32.5-35.5)		
Oerlemans et al	Diatek 9000 IR- thermometer	25	15	palmar & dosal hand	Middle of 3rd metacarpal	13 subjects (6 men, 7 women)	21-44 (mean:30)	34.0±1.3	33.8 ± 1.4	32.9 ± 1.4	33.1 ±1.4

Table 3
Reference temperature of the palmar or dorsal surface of fingers, healthy subjects or non-symptomatic controls

Publication	Temperature measurements	Participants					
	equipment	Room temperature (C°)	AcclimationTime (min)	view	Region of interest	gender	Age (years)
Kolosovas-Machuca & González	FlexCam-S	22 ± 1	15	Total body	Spot, palmar, dorsal finger	25 children (15 boys,10 girls9	2 -15 (mean 7.8)
Snekhalatha	ThermaCAM T400 (FLIR)	20	15	Right hand, anterior view	Rectangular MCP1-MCP5 IP; PIP2-PIP5 DIP2-DIP5	15 healthy men	Mean 45.5±11.8
Gatt et al	FLIR Model SC 7000;	22.6± 0.39	20	hand, anterior view	Circle, finger pulp	63 subjects (24 men and 39 women)	Mean 36 ± 12.24
Niu et al	Avionics TVS-2000	21 ± 1	20	Total body	Polygon, All fingers: MCP-joints to finger tip	57 subjects (35 men,22 women)	24 - 80
Zhu & Xin	AGEMA Thermovision 470 Pro	25	30	NA	NA	223 subjects (138 males 85 females)	42.5 ± 8.8
Leijon-Sundqvist et al	FLIR® A320	23°C ± 1	30	hand, anterior view	3 polygons digit 2-5 2 polygons digit 1	232 hands (67 men)	23 ± 3
Ammer	Agema 870	24	10	Arm in 90 ° shoulder abduction, elbow in 90 °flexion, palm looking towards the camera	Circle at all fingertips and MCP-joints	19 non-symptomatic hands (5 men,15 women)	23 to 50
Sivanandam et al	ThermaCam FLIR T400	23	14	Forearm with hand	Spot at fingertip, line at total finger	32 healthy subjects	40 ± 12

Publication	Temperature findings mean ± SD (95% CI) Right hand (or average of both hands)									
	Thumb		Index finger		Middle finger		Ring finger		Little finger	
Kolosovas- Machuca& Gonzales	volar	dorsal	volar	dorsal	volar	dorsal	volar	dorsal	volar	dorsal
	30.2 ± 1.9	30.8 ± 1.6	30 ± 1.9	30.4 ± 1.7	30.1 ± 1.8	30.5 ± 1.9	29.9 ± 1.9	30.2 ± 1.9	29.3 ± 2.1	29.9 ± 1.9
Zhu & Xin										
Distal phalanx	26.9 ± 0.8	26.9 ± 0.84	26.8 ± 0.66	26.8 ± 0.68	26.8 ± 0.61	26.8 ± 0.60	26.7 ± 0.62	26.8 ± 0.69	26.7 ± 0.65	26.7 ± 0.80
Middle phalanx			31.2 ± 2.03	30.6 ± 2.18	31.1 ± 2.06	30.5 ± 2.17	30.8 ± 2.20	30.5 ± 2.17	30.4 ± 2.24	30.1 ± 1.97
Proximal phalanx	31.3 ± 1.89	31.1 ± 1.80	31.7 ± 1.63	30.7 ± 1.67	31.6 ± 1.61	30.9 ± 1.74	31.4 ± 1.69	31.0 ± 1.73	30.9 ± 1.97	30.7 ± 1.63
Gatt et al										
Finger tip	27.6 ±3.2		27.4 ± 3.2		27.0 ± 3.1		26.9 ± 3.1		26.8 ± 3.2	
Ammer										
MCP	29.9 ± 2.7 (28.6 to 31.2)		29.0 ± 3.0 (27.6 to 30.5)		29.6 ± 2.8 (28.3 to 31.0)		29.5 ± 2.9 (28.2 to 30.9)		29.0 ± 2.9 (27.6 to 30.4)	
Finger tip	27.5 ± 3.3 (25.6 to28.9)		27.4 ± 3.3 (25.8 to 28.9)		27.3 ± 3.3 (25.7 to 28.9)		27.2 ± 3.1 (25.7 to 28.8)		27.2 ± 3.2 (25.6 to 28.7)	
Snekhalatha et al (average of both hands)										
MCP	33.9 ± 0.3		33.9 ± 0.2		33.6 ± 0.2		33.8 ± 0.2		33.9 ± 0.2	
PIP			33.8 ± 0.2		33.7 ± 0.2		33.7 ± 0.2		33.7 ± 0.1	
DIP	33.9 ± 0.4		33.9 ± 0.2		33.6 ± 0.4		33.6 ± 0.3		33.8 ± 0.1	

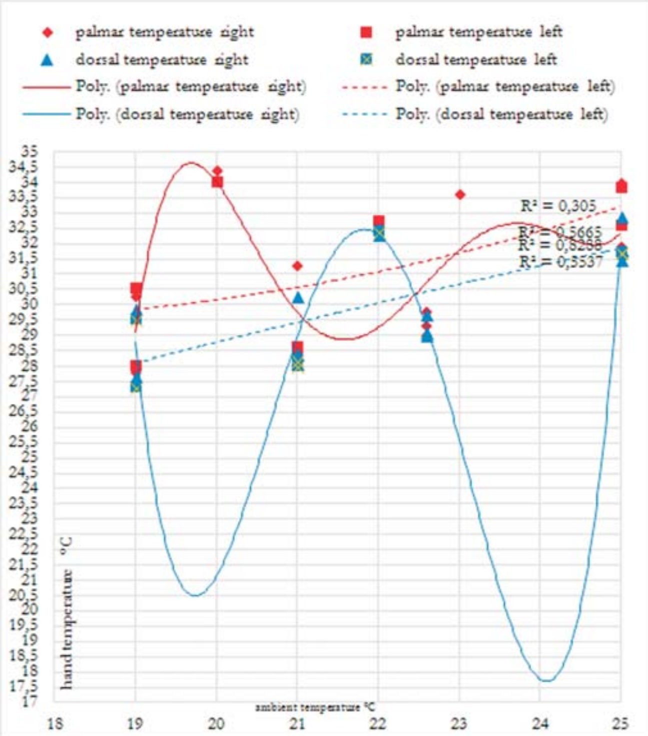
Table 3
Continued

Publication	Temperature findings mean ± SD (95% CI) right hand									
Kolosovas-Machuca & Gonzales	Thumb		Index finger		Middle finger		Ring finger		Little finger	
	volar	dorsal	volar	dorsal	volar	dorsal	volar	dorsal	volar	dorsal
	30.2 ± 1.9	30.8 ± 1.6	30 ± 1.9	30.4 ± 1.7	30.1 ± 1.8	30.5 ± 1.9	29.9 ± 1.9	30.2 ± 1.9	29.3 ± 2.1	29.9 ± 1.9
Zhu & Xin										
Distal phalanx	26.9 ± 0.8	26.9 ± 0.84	26.8 ± 0.66	26.8 ± 0.68	26.8 ± 0.61	26.8 ± 0.60	26.7 ± 0.62	26.8 ± 0.69	26.7 ± 0.65	26.7 ± 0.80
Middle phalanx			31.2 ± 2.03	30.6 ± 2.18	31.1 ± 2.06	30.5 ± 2.17	30.8 ± 2.20	30.5 ± 2.17	30.4 ± 2.24	30.1 ± 1.97
Proximal phalanx	31.3 ± 1.89	31.1 ± 1.80	31.7 ± 1.63	30.7 ± 1.67	31.6 ± 1.61	30.9 ± 1.74	31.4 ± 1.69	31.0 ± 1.73	30.9 ± 1.97	30.7 ± 1.63
Gatt et al										
Finger tip	27.6 ±3.2		27.4 ± 3.2		27.0 ± 3.1		26.9 ± 3.1		26.8 ± 3.2	
Ammer										
MCP	29.9 ± 2.7 (28.6 to 31.2)		29.0 ± 3.0 (27.6 to 30.5)		29.6 ± 2.8 (28.3 to 31.0)		29.5 ± 2.9 (28.2 to 30.9)		29.0 ± 2.9 (27.6 to 30.4)	
Finger tip	27.5 ± 3.3 (25.6 to28.9)		27.4 ± 3.3 (25.8 to 28.9)		27.3 ± 3.3 (25.7 to 28.9)		27.2 ± 3.1 (25.7 to 28.8)		27.2 ± 3.2 (25.6 to 28.7)	
Publication	Temperature findings mean ± SD (95% CI) left hand									
Kolosovas-Machuca & Gonzales	Thumb		Index finger		Middle finger		Ring finger		Little finger	
	volar	dorsal	volar	dorsal	volar	dorsal	volar	dorsal	volar	dorsal
	30.4 ± 1.6	30.6 ± 1.6	30 ± 1.8	30.2 ± 1.9	30.2 ± 1.6	30.2 ± 1.9	30 ± 1.8	30.2 ± 2	29.7 ± 2	29.6 ± 2.1
Zhu & Xin										
Distal phalanx	26.8 ± 0.5	26.9 ± 0.7	26.8 ± 0.62	26.8 ± 0.8	26.8 ± 0.7	26.9 ± 0.8	26.8 ± 0.6	26.9 ± 1.0	26.7 ± 0.6	26.7 ± 0.8
Middle phalanx			30.7 ± 2.2	30.3 ± 2.2	30.8 ± 2.1	30.3 ± 2.24	30.3 ± 2.2	30.1 ± 2.2	30.4 ± 2.2	29.7 ± 2.10
Proximal phalanx	31.2 ± 2.0	31.0 ± 1.8	31.2 ± 1.8	30.6 ± 1.6	31.4 1 ±1.7	30.6 ± 1.63	31.3 ± 1.73	0.8 ± 1.8	30.9 ± 1.9	30.5 ±1.7
Gatt et al										
Finger tip	27.5 ±3.2		27.3 ± 3.1		26.9 ± 3.0		26.8 ± 3.0		26.8 ± 3.0	
Ammer										
MCP	33.3 ± 2.1 (32.3 to 34.3)		33.1 ± 2.1 (32.2 to 34.1)		33.2 ± 1.9 (32.3 to 34.1)		32.8 ± 2.0 (31.9 to 33.7)		32.4 ± 2.4 (31.3 to 33.5)	
Finger tip	31.9 ± 2,8 (30.8 to 33.0)		31.8 ± 2.9 (30.4 to 33.1)		31.6 ± 2.8 (30.3 to 32.9)		31.5 ± 3.4 (29.9 to 33.0)		30.6 ± 2.9 (29.3 to 31.9	
Temperature findings mean ± SD (95% CI) both hands										
Niu et al	Palmar digits (both hands):					dorsal digits (both hands)				
	30.3 ± 2.2 (24.1 to 34.5)					30.2 ± 2.0 (24.8 to 34.3)				
Leijun-Sunqvist	Thumb (both hands)		Digits 2 to 5 (both hands)							
QR	30.6 ± 1.5		29.4 ± 1.5							
SR	25.9 ± 2.9		24.6 ± 2.9							
Sivanandam et al. (mean of all measurement sites at fingers ?)					Finger tip			Total finger		
					32.4 ± 2.4			32.7 ± 2.2		

Table 4
Palmar hand or finger temperatures of patients before and after interventions

Publication	Temperature measurements: equipment	Room temperature (C°)	Acclimation Time (min)	view	Region of interest	Participants: Gender, disease intervention	Age (years)	Temperature findings (°C): palmar right	palmar left	Rectal
Yamakage et al	FirstTemp Genius™ Infrared thermometer	23.2 ± 0.7	NA	right hand	mid palm	60 patients prior to spinal surgery,	58 ± 10	30.2°± 2.6° (25.6–35.4).		37.1 ± 0.4
								Difference to baseline temperature-		
						After 1 hour anaesthesia		Significant linear relationship (r=0.69) between palmar temperature and decrease in rectal temperature	-0.50 ± 0.27	
						After 2 to 3 hours of anaestesia		No significant linear relationship (r=0.067) between palmar temperature and decrease in rectal temperature	-0.39 ± 0.29	
Koskinen et al	Thermistor PF440 Peritemp 4005 (Perimed)	20 to 22	NA	middle finger	pulp	13 men,18 women with palmar hyperhidrosis	27.5 ± 1.3	Mean ± SEM		
						before S.E.		27.7 ± 0.6	27.6 ± 0.6	
						after S.E.		34.6 ± 0.2	34.6 ± 0.1	
Chiou &Chen	TM-200D Bi-Temp thermometer	NA	NA	both hands	thenar	14 men, 36 women with palmar hyperhidrosis	25 ± 11 (14 - 48)	Mean ± SEM		
						Before S.E.		31.4 ±0.3*	31.6 ±0.3*	
						Immediately after S.E.		32.1 ±0.3*	31.8 ±0.3*	
						5 min after S.E.		32.7 ±0.2*	32.4 ±0.2*	
						10 min after S.E.		32.8 ±0.3*	32.5 ±0.4*	
Eisenach et al	400 Series Thermistor	NA	NA	Index finger	pulp	2 men, 8 women with palmar hyperhidrosis	18 - 57	Mean ± SEM		
						before S.E.		33.7 ± 0.4	33.3 ± 0.6	
						4 to 6 min after S.E.		34.5 ± 0.2	34.9 ± 0.3	
Crandall et al	Thermocouple Sable Systems	NA	NA	both hands	thenar	4 men, 7 women with palmar hyperhidrosis	27 ± 3	Mean ± SEM		
						before S.E.		31.0 ± 0.5		
						5 min after S.E.		31.3 ± 0.5		
						10 min after S.E.		32.2 ± 0.4		
						15 min after S.E.		32.8 ± 0.3		
						33 min after S.E		33.8 ± 0.3		

Figure 1
Scatterplott between ambient and hand temperatures



ning system. The size of focal plane arrays varied in a range between 120x180 to 360x 256 pixels. The wavelength sensitivity was in the infrared mid-waveband in 1 detector, in the long-waveband in 6 detectors and unclear in one camera.

Type of thermometer

Contact thermometers are the standard devices for monitoring hand temperature during anaesthesia and surgery. However, 2 infrared tympanic thermometers have been used for that purpose. Both have been tested in anaesthetized patients undergoing surgery [37] or in postoperative care [38]. The DIATEC device was also used to estimate hand temperature of patients with complex regional pain syndrome [39] or Charcot-Marie-Tooth disease [40]. The validity of core temperature estimates based on tympanic and forehead temperatures was questioned [41]. The validity of local skin temperatures obtained by hand-held infrared thermometers is not determined.

Ambient temperature

Information on ambient temperature were provided in all papers reporting diagnostic studies, but such an information was only available in 2 out of 6 surgical papers The ambient temperature varied across the studies between a minimum of 19°C [13] and a maximum of 25°C [15, 16,21,25].

Acclimation time

Only subjects who participated in diagnostic thermographic studies acclimated prior to image recording.4 different periods for acclimation were described. 15 minutes were reported in 6 papers [14,17,18,23,24,25], 20 minutes in 5 studies [13,15,16,19,20], 30 minutes in 2 publications [21, 22] und 10 minutes in 1 paper [26].

Reference values: Palm and dorsum of the hand

Palmar hand temperatures were derived from 6 studies which reported reference temperatures in various anatomical regions of the human body and 3 studies that investigated the intensity of hand temperature in healthy subjects. From 3 other studies, which investigated patients with rheumatoid arthritis, diabetes mellitus and cardiovascular risk factors, hand temperatures of healthy control subjects were included. In 4 studies hand temperatures were derived from total body thermograms and from upper body views in 2 papers. In 1 paper spot temperatures were measured at the middle of the 3rd metacarpal bone with a radiometric infrared thermometer, in another publication both hands were imaged simultaneously from the wrist to the finger tips. The image of the unilateral hand with a portion of the forearm was recorded in 3 papers.

Data from 518 men and 441 women and 25 children (15 boys and 10 girls), in total 1016 subjects were included. Analysis of pooled hand temperatures was not performed due to inhomogeneity in body position during image recording, field of view, camera specifications and ambient temperature. Palmar temperatures of the right hand were available from 949 participants and ranged between 27.8 ± 2.1°C at an ambient temperature of 19°C [13] and 34.1 ±0.7 °C at 20°C [24]. Both hands were investigated in 662 subjects and in 6 of 8 studies side-to-side differences in palmar temperatures were equal or less than 0.2°C. 2 papers reported a difference in mean temperature of 1.0 and 0.8°C between the left and the right hand (table 2).

The temperature of the dorsal hand was obtained from 828 subjects. The side-to-side difference in temperature was of similar magnitude as recorded at the palmar aspect of the hands. However, the mean dorsal hand temperature was by 0.2 to 1.1°C less than the palmar temperature.

The diagram in figure 1 shows the scatterplot between ambient and hand temperatures generated in Microsoft Excel, and various trendlines have been added for graphical analysis of the relationship between ambient and hand temperatures.. Polynomial regession achieved the highest R^2-values. The relationship between palmar and dorsal hand and ambient temperature is almost linear, but the curves of the right hand were neither similar between dorsal and palmar hand nor to the trend lines of the left hand. It is obvious that the hand temperature readings are not drawn from a homogeneous population.

Reference temperatures: Finger

Table 3 summarises temperature readings from the digits. Finger temperatures have been recorded from 486 adults (284 men, 282 women) and 25 children. The site of measurement varied across studies: 2 studies measured the temperature at finger pulp and the volar circumference of each metacarpophalangeal (MCP) joint [19,26]. Zhu et al. recorded the temperature at the distal, middle and proximal finger phalanges from both the volar and dorsal surface [21]. Niu et al. used a polygon that enclosed all long fingers from the MCP-joint to the fingertip [20]. Sivanandam et al. measured at the fingertip and along a line located at the longitudinal finger axis [22]. Leijon-Sundqvist et al reported for both hands mean temperatures of thumbs and long fingers in relation to the time needed to recover from a cold challenge [23]. Spot temperatures of the dorsal and volar surface of each finger were recorded in children [17].

No common information could be extracted related to the temperature differences of individual finger between right and left hand. It was also not possible.to compare the skin temperatures of dorsal and volar surface of the fingers.

Monitoring hand temperature in surgery

Although it was claimed, that hand temperature measurement is an established method for monitoring thoracic sympathectomy a standard defining the temperature device and the anatomical site of temperature measurement at the hand is not available or are not used in that condition. 5 papers were selected as examples for monitoring hand temperature in neurosurgery (table 4).

1 author used an infrared fever thermometer for continuous recording of hand temperature at the mid of the palm in 60 patients undergoing spinal surgery [27]. The 4 other publications used contact thermometers for monitoring sympathectomy in a total of 102 subjects suffering of palmar hyperhydrosis.

Only one study showed a large increase of approximately 7°C in pulp temperature of the middle finger after sympathectomy [28]. In the other 3 papers the change of index finger or thenar temperature was less pronounced with temperature rises between 0.3 to 0.8°C at 5 minutes after sympathectomy [29-31].

Infrared thermography was used as outcome measure for successful sympathectomy in patients with palmar hyperhidrosis [44-47]. The time point in recording the postoperative image remained unclear in all referenced paper. Postoperative increase of hand temperature is in the range between 3 and 5°C. 2 days after surgery, an individual patient presented with a large temperature rise of 9°C [48]. It takes at least 30 minutes after dissection of sympathetic nerve fibres until the temperature, measured with thermocouples at the thenar, is approximately by 3.0 C° higher than baseline readings.

Discussion

The original intention of this manuscript was to write a systematic review. However, due to a low number of hits in the pilot search, it was changed to a narrative review with some features of a systematic review. Most studies investigating the course of hand and finger temperatures are focused on the dorsal surface of the hand. A systematic review on the use of a cold challenge to provoke vasospasms in the finger vasculature identified 51 papers, but only 8 reported temperature readings from the volar site of the hands [47].

Hand arthritis is one of the oldest application of infrared thermography and the dorsal aspect of the hand was the preferred view for imaging. Some examples are the paper by Ring and Collins who used their developed thermographic index to evaluate anti-inflammatory drugs effects in patients with symptoms of rheumatoid hand arthritis [48]. Engel published reference temperatures recorded at the dorsal circumference of finger joints in healthy subjects and arthritis patients [49]. Ammer published temperature values recorded in healthy subject or non-symptomatic joints of patients with osteoarthritis or inflammatory arthritis from the regions of MCP, proximal (PIP) and distal interphalangeal (DIP) joints [50]. Joint inflammation and entrapment of peripheral nerve such as carpal tunnel syndrome or thoracic outlet syndrome affect the hand temperature.

The reason for the wide variation in study designs of the current review might be caused by the lack of an internationally agreed standard for recording and evaluation of infrared thermal images in medicine and related. As the size of the measurement area affects the reproducibility of infrared based temperature readings, it can be questioned how valid hand temperatures are if they have been obtained from thermograms of the total body. A previous study obtained significantly different temperature readings when the size of the measurement area differed by 100 or more percent [51]. It was recently shown, that the agreement of temperature readings from the thigh derived from total body or regional thermograms is poor with a mean difference of 1.1°C and limits of agreement between -0,7 and 2.9 [52]. Palmar temperatures obtained from small measurement areas in total body thermograms should not be compared to temperatures derived from hand thermograms in which the area of the hand represents 70 to 80% of the total image area. Another disadvantage of total body thermograms is the correct selection of the thermal window. If the total body image is recorded at low ambient temperature, the hand temperature might already be on the lower edge of the recording window of the camera and therefore difficult to be separated from the background as visible in a paper by Costa et al [53].

One argument for recording the hand temperature from the volar side is the difference in thermoregulatory response of glabrous and non-glabrous (=hairy) skin. The non-hairy palmar skin response differently to noxious heat stimuli than the hairy skin of the dorsal hand. There are also differences in temperature thresholds that induce a local vascular response [54]. However, recording hand temperatures with an infrared camera does not prove that such an image represents the distribution of thermoreceptors and their input into the thermoregulatory system. Taylor et al provided a list of conditions which must be met by a measurement procedure that their result might be assumed as meaningful surrogate of the thermo-afferent feedback [55]. None of these characteristics are features of infrared thermal imaging.

A recent review on applications of thermal imaging in plastic surgery did not include publications that reported the use thermography for monitoring patients during or following sympathectomy [56]. Many papers related to thermographic monitoring of thoracic sympathectomy have been published in the Korean language and although they show an abstract in English, they have been excluded from this overview because the thermographic findings were only described in terms of temperature increase or decrease. Intraoperative monitoring is rarely performed by infrared thermography, although a case report of this application has been published [36].

There is ample space for the improvement in design and reporting of thermography studies. Principal requirements for conducting diagnostic studies must be considered and the guidelines for reporting trials should be considered [57]. Reference values of regional skin temperatures must be derived from sufficiently large measurement areas and thermal images that show as much as possible from the ana-t omical region of interest. For a better understanding of the consequences of sympathectomy, the relationship between temperature changes and other measures of the sympathetic nerve activity should be investigated.

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Publication Output of EAT board members between October 2015 and November 2016

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SUMMARY

This short survey reports the contribution of EAT board members to publications on thermology or temperature measurement in the period October 2015 to November 2016. A literature search in the databases Scopus, Google Scholar, ResearchGate and the journal Thermology international identified in total 86 papers, comprising 20 full length papers in journals, 15 conference abstracts published in journals, 2 books and 49 book chapters. Papers on thermology represent 54 to 100 percent of the publication activity of individual board members. R. Vardasca was first author of 21 articles and co-author in 15 other papers. Distribution of skin temperature in athletes was the predominant topic in full length papers.

KEY WORDS: thermology, scientific journal, thermal imaging, publication type, sports

VON EAT-VORSTANDSMITGLIEDERN VERFASSTE PUBLIKATIONEN IM ZEITRAUM OKTOBER 2015 BIS NOVEMBER 2016.

Diese kurze Übersicht berichtet den Beitrag der EAT Vorstandsmitglieder zu Publikationen über Thermology oder Temperatur Messung im Zeitraum Oktober 2015 bis November 2016. Eine Literaturrecherche in den Datenbanken Scopus, Google Scholar, ResearchGate und der Zeitschrift „Thermology international“fand insgesamt 86 Publikationen, die 20 Volltextartikel in Fachzeitschriften, 15 Konferenz-Abstracts, die in Zeitschriften veröffentlicht wurden, 2 Bücher und 49 Buchkapitel umfassten. Thermologische Publikationen repräsentieren 54 bis 100 Prozent der Publikationstätigkeit der einzelnen Vorstandsmitglieder R. Vardasca war Erstautor von 21 Artikeln und Co-Autor in 15 anderen Beiträgen. Die Verteilung der Hauttemperatur bei Sportlern war das vorherrschende Thema in den Volltextartikeln.

SCHLÜSSELWÖRTER: Thermologie, Fachzeitschrift, Thermographie, Publikationstyp, Sport

Thermology international 2016, 26(4) 117-122

Introduction

One aim of the European Association of Thermology (EAT) is the promotion of temperature measurements, particularly those based on infrared thermal imaging, as a diagnostic method and/or outcome measure in bio- medicine and related sciences. Papers published in journals that provide a rigorous peer review, generate evidence on the validity and reliability of any measurement method which is the required basis of an established evaluation technique.

In September 2015, a new board of the EAT was elected and all board members agreed to put more afford in promotion of thermology. This short report describes the contributions of EAT board members to the body of knowledge of evidence based thermology for the period October 2015 to November 2016.

Method

In the databases Scopus, Google Scholar and ResearchGate papers were identified that have been authored by any of the current EAT board members i.e. "Howell K", "Jung A", "Vardasca R", "Ammer K", "Sillero Quintana M" and "Seixas A". The period of interest was the time between October 2015 to November 2016. A hand search for papers of the above authors was performed in all issues of the journal Thermology international published since October 2015.

The found papers were separated by the topic of the publications i.e. whether thermology was an applied technique or not. For each author, a profile related to thermology papers was created and presented in a table. The profile included the rank of author in the publication such as first author or co-author, type of publication (topical review, controlled study, observational study, editorial, conference abstract, extended conference abstract, report, publication review, chapter in conference proceedings, book chapter, book). The source of publications is shown and the main messages of the publication are reported.

Results

Of 111 papers found, 83 were related to thermology. The contribution of each author is shown in table 1. 4 topical reviews, 1 controlled study and 9 observational studies have been published in the period of interest. The most diligent author was R. Vardasca with 36 papers, most of them are book chapters.

The proportion of thermology papers in relation to the total number of published papers varies between authors in a range of 0.54 to 1.0.

The total number of published papers of each author is obviously affected by the number of book included chapters.

Table 1
Total of papers published in 2016

Author	K Howell	A Jung	R Vardasca	K Ammer	M Sillero Quintana	A Seixas
papers not related to thermology	2	10	2	11	0	3
thermology papers in total (Without book chapters)	11 [1-11]	16 [12-27] (3)	36(28-62] (11)	13[63-75] (7)	7 [76-82] (6)	8[33,54,59,60,62,84-86]
thermology papers/total papers	11/13=0.85	16/26=0.63	36/38=0.95	13/24=0.54	7/7=1	8/11=0.73
First author	1	7	21	10	2	6
topical review			1	2	1	
controlled study		1				
observational study	3		2	1	4	1
conference abstract	5		4			2
extended conference abstract		1	1	2	1	2
report			1			
editorial				1		
Publication review	1		1			1
Book chapter		13	22	6	1	
Proceedings chapter	3		3	1		2
Book co-editor		1	1			

After subtracting the number of book chapters from the total of thermology papers, the number of publication on thermology varied between 3 and 11, indicating a similar number of annually published thermology papers by each board member.

Source of publication

2 books were dedicated in total to thermology. "Thermal Imaging, a casebook in clinical medicine" edited by Francis Ring, Anna Jung and Janusz Zuber, was published by IOP Publishing in Bristol as a printed version and as an e-book [14]. Kevin Howell stated that "the Casebook is one of the most comprehensive collections of clinical thermography cases ever published in one text, and would be a valuable addition to any thermographer's bookshelf" [1].

A group of engineers and medical doctors edited the book "TERMOGRAFIA - Imagem Médica e Síndromes Dolorosas" in portoguese language for the publisher Lidel, Lisabon [41]. This book is similar in structure as the IOP casebook, but its focus is the application of infrared thermal imaging in various pain syndromes.

Thermology papers authored by EAT board members are part of the following 3 conference proceedings: Occupational Safety and Hygiene IV [40, 83], IFMBE proceedings [5] and QIRT 2016 [8, 9, 62, 63, 73].

Full length papers and abstracts were published in 12 different journals. The highest number of papers appeared in Thermology international comprising 3 reviews [31,64,65], 3 paper reviews [1,30,84). 1 report [28], 1 editorial [75], 2 observational studies [33,66] conference abstracts [2-4, 29] and extended conference abstracts [13, 32, 75, 76, 82].

Full length papers appeared in Clinical and Experimental Rheumatology [11], Journal of Medical Imaging and Health Informatics [12,77]. Infrared Physics and Technology [34], Revista Internacional de Medicina y Ciencias de la Actividad Fisica y del Deporte [78], Journal of the Royal Army Medical Corps [79], Asian Journal of Sports Medicine [80] and Journal of Thermal Biology [81]. 2 observational studies in horses were published in the Journal of Equine Veterinary Science [6] and the Animal Science Journal [7].

Conference abstracts appeared in the journals Annals of Rheumatic Diseases [10], BMC Health Services Research [59, 60] and Journal of Sleep Research [61].

Topic of papers: reviews

4 review papers have been published, 2 reviews were dedicated to papers published on thermology or temperature measurements [63,64). The role of thermography in breast cancer imaging was the topic of one paper [31] and applications of thermal imaging in sports were reported in another review paper [76].

Topic of papers: controlled studies

Anna Jung's group investigated the effectiveness of heated surgical mattresses to prevent heat loss of patients undergoing general anaesthesia [12]. The agreement of oesophageal temperature with the temperature at the inner canthi of the eye obtained with infrared thermal imaging was the secondary outcome of this study. A decrease in mean oesophageal temperature was observed 90 minutes after intubation of ~0.5°C in warmed patients and a fall of mean temperature of ~ 0.7 was recorded in non-warmed patients. The corresponding differences in eye temperatures of warmed patients ~ 0.3 and ~0.6 in non-warmed control subjects. A significant correlation between oesophageal and eye temperatures was found, although the inner canthi temperature was prior to intubation by ~0.9°C below the oesophageal temperature.

Topic of papers: observational studies

A study co-authored by Ricardo Vardasco investigated the thermal patterns in a small group of patients with various grades of ligament injuries of the ankle [34]. The authors reported a trend of increased temperature difference to the non-injured ankle in more severe than in minor injuries, however a statistically significant temperature difference was not obtained.

Aderito Seixas et al. studied the relationship of the local skin temperature over the arm biceps to anthropometric variables such as body mass index (BMI) and skin fold [33]. Significant differences in temperature values were found between groups based on the arm fat percentage of the subjects, but moderate and non- significant correlations were found between skin temperature and other anthropometric measures such as body mass index, upper arm circumference, upper arm area, the bicipital skinfold, the arm fat percentage and the arm lean mass.

Manuel Sillero and co-workers reported the skin temperature distribution in a large sample of 201 patients who attended the emergency department of clinic specialised in trauma care [77]. Although the group was not homogeneous related to the time lag between the actual injury and the visit at the clinic, and the diagnostic labelling of patients is debatable, a difference in mean temperature of 0.5°C between the injured and the corresponding non-injured site warrants further investigations in the validity of thermal imaging in traumatology.

Manuel Sillero was co-author of a paper, which reported daily oscillations of skin temperature in military personnel from Brazil [78]. Thermal images of the upper and the lower body were recorded in the anterior and posterior view at 7, 11, 15, 19 and 23 h from young male adults using a Fluke IRT-25 camera with sensitivity of <0.1°C and focal plane array of 160×120 pixels. In total of 25 regions of interest were defined, 8 in the anterior upper body view, 9 in the posterior upper body and 4 in each lower body views. The anterior hands showed the greatest variation in skin temperature throughout the day. The lowest mean skin temperatures were obtained in the early morning, with increases in the afternoon and plateauing after 15:00.

Another study co-authored by Manuel Sillero, investigated the change of local skin temperatures 30 minutes before, during 1 hour of moderate intensity exercise on a treadmill and for 60 minutes after exercise [79]. Prior to the exercise, the mean temperatures of all 28 regions of interest (ROI) were stabilised as they did not show much variation. A significant reduction of skin temperature was observed in most ROIs after 10 minutes of activity, except for the lower extremities. Compared to pre-exercise, skin temperature of the palmar hands was significantly increased throughout the first 35 minutes after exercise cessation.

The final paper showing Manuel Sillero as co-author reported the validity of inner canthus temperature recorded by infrared thermography as a surrogate measure for core temperature at rest, during exercise and recovery [80]. The agreement of intestinal core temperature with infrared based temperature of the inner canthus of the eye was determined in twelve physically active males rested for 30 min prior to exercise, performed 60 min of aerobic exercise at 60% VO_{2max} and passively recovered a further 60 min post-exercise. Mean differences between canthus temperature and intestinal temperature were -0.61 °C during pre-exrcise, -1.78 °C during exercise and -1.00 °C during post-exercise. The authors concluded, that the temperature of the inner canthus is not a valid substitute measurement for telemetrically obtained intestinal temperature as used in sports and exercise physiology.

Kevin Howell was co-author of two papers that reported surface temperature changes in horses after physical exercise. A study conducted in racehorses concluded that eye temperature is a poor estimate of core temperature due to limited agreement with rectal temperature [6]. No correlation was found between eye temperature and accepted measures of stress such as salivary cortisol concentration and heart rate.

The other study investigated the influence of breed, age, gender or training intensity level and ambient temperature on the surface temperature in different anatomical regions of the studied horses [7]. The authors concluded that ambient temperature, breed and training level contribute to racehorse body surface temperature in some areas of the distal parts of the forelimbs and the back, but gender or age do not predict surface temperatures.

Kevin Howell was also involved in an observational study that described clinical features of patients suffering from the rare disease erythromelalgia [11]. Raynaud's phenomenon was prevalent in 80% of 46 patients. Cold induced vasospastic response in fingers or toes was evaluated by infrared thermography in a subsample of 20 subjects with 1 false negative and 3 false positive thermographic findings.

Discussion

An impressively high number of 85 papers were found that have been authored or co-authored by board members and published within the first year of the function period of the new EAT board. Many of these studies have been conducted and authored in combination with other active EAT members.

The identified publications indicate the high engagement of the EAT board members in promotion of thermology. This becomes visible in participation in thermology conferences, and presentations in other congresses dedicated to medical fields where temperature measurement or thermal imaging are of potential benefit.

Well designed observational studies and controlled trials, published in peer reviewed journals are the basis for raising and establishing evidence of the validity of clinical thermometry and thermal infrared imaging. Despite some shortcomings in design, the studies authored by EAT board members are valuable contributions to the scientific basement of thermology.

The two casebooks endorse the necessary process of standardisation of clinical thermography and provide information for the direction of further thermological research in medicine and related fields. A particularly promising field is research related to the use of quantitative thermal imaging as outcome measure in clinical trials.

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Infrared Space Missions and Surveys*

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William Herschel, following his discovery of the planet Uranus in 1781, made an even more important discovery in 1800 - of an invisible form of light now known as infrared: IR. He wanted to know how much heat was passed through the different coloured filters he used to observe sunlight. To this end he discovered infrared light by directing sunlight through a glass prism to create a spectrum and then measured the temperature of each colour. Herschel used three thermometers with blackened bulbs and, for each colour of the spectrum, placed one bulb in a visible colour while the other two were placed beyond the spectrum as control samples.

As Herschel measured the individual temperatures of the violet, blue, green, yellow, orange, and red light, he noticed that all of the colours had temperatures higher than the controls. Moreover, he found that the temperatures of the colours increased from the violet to the red part of the spectrum. After noticing this pattern Herschel decided to measure the temperature just beyond the red portion of the spectrum in a region where no sunlight was visible. To his surprise, he found that this region had the highest temperature of all.

The Sun's IR component is partially absorbed by water vapour and CO_2 in the Earth's atmosphere. Inevitably, the less intense IR from other celestial objects is fully absorbed by our thick atmosphere and, given that IR detectors require cryogenic cooling, infrared astronomy had to wait a long time before becoming practical. Subsequently it has become a dominant form of astronomy. In the late 1960s sounding-rockets were used to get above the atmosphere, then IR observatories were built on mountain peaks and telescopes were flown on aircraft. Beginning in 1983 IR space observatories arrived on the scene. Unfortunately, the lifetime of IR space observatories- eleven of which have been launched by the US, Europe and Japan - is typically much shorter than for other science spacecraft because they have relied on the cryogenic cooling of the detectors. This is about to change: the James Webb Telescope with its 6.5 m mirror, scheduled for launch in 2018, will use a sunshield instead of cryogenic cooling, and therefore promises a long lifetime.

The Infrared Processing and Analysis Center (IPAC) at Caltech in Pasadena is dedicated to science operations, data archives, and community support for astronomy and solar system science missions, with a historical emphasis on infrared-submillimetre astronomy and exoplanet science. It is the place to go to stay up-to-date in this field of astronomy.
http://coolcosmos. ipac.caltech.edu/infrared_m ission

Infrared Astronomy is the detection and study of heat energy- black body radiation - emitted from objects in the Universe. Every object that has a temperature above absolute zero radiates in the infrared. So, infrared astronomy involves the study of just about everything in the Universe. In the field of astronomy, the infrared region lies within the range of sensitivity of infrared detectors, which is between wavelengths of about 1 and 300 microns.

In space, there are many regions that are hidden from optical telescopes because they are embedded in dense regions of gas and dust. However, infrared radiation, having wavelengths that are much longer than visible light, can pass through dusty regions of space without being scattered. This means that we can study objects hidden by gas and dust in the infrared, which we cannot see in visible light, such as the centre of our galaxy and regions of newly forming stars.

Early Sounding-Rocket Experiments

Throughout the late 1960s and 1970s a number of rocket-borne experiments launched infrared detectors above the Earth's atmosphere. hese pioneering missions, including such projects as FIRST, HI STAR, FAIR, SCOOP, SOFT, & DOT, helped researchers get their bearings in the mid-infrared sky. Primarily funded by the U.S. Air Force, these projects very much set the stage for later generations of space-based observatories.

1968 Learjet Infrared Telescope

Astronomer Frank Low led a project that flew a 12" infrared telescope on a NASA Learjet. Flying above most of the infrared-absorbing atmosphere provided a stable platform for targeted Observations of sources like planets. One key result was the discovery that both Jupiter and Saturn put out more heat than they receive from the Sun, suggesting they have an internal heat source.

1968 Two-Micron Sky Survey

The Two-Micron Sky Survey (TMSS) was the first large-area nearinfrared survey of the sky. It was carried out by a team at the Mt.Wilson Observatory, led by Caltech researcher Gerry Neugebauer..

The survey covered approximately 75% of the sky and discovered around 20,000 infrared sources, including star-forming regions, galaxies, thecentre of our Galaxy, and many stars. The team used liquid-nitrogencooled PbS (lead sulphide) detectors, which were mostsensitive to infrared light at a wavelength of 2.2 microns.

1974 Kuiper Airborne Observatory (KAO)

The Kuiper Airborne Observatory (KAO) was a C-141A jet aircraft that carried an infrared telescope into the upper atmosphere, to altitudes of 12,500 m (41,000 ft). At these heights, the telescope was above 99% of the infrared-absorbing water vapour in the atmosphere, giving the KAO a relatively unobstructed view of the infrared sky. The KAO flew missions for 20 years, and was responsible for discovering the faint rings of Uranus in 1977, and the presence of water in the atmospheres of Jupiter and Saturn.

1979 NASA Infrared Telescope Facility (IRTF)

The IRTF is one of NASA's leading ground-based infrared observatories. It was built in 1979, specifically to support Voyager's encounters with Jupiter and Saturn. Today, half its time is still used by astronomers to observe every kind ofthing in the Solar System, including the atmospheres and satellites of the major planets, the volcanoes on Io, the clouds of Titan, the asteroid belt, comets, and Near-Earth Objects (asteroids that come very close to the Earth). The IRTF is located on the summit of Mauna Kea, on Hawai'i, and is funded by NASA and the US National Science Foundation.

1979 United Kingdom Infrared Telescope (UKIRT)

The United Kingdom Infrared Telescope, UKIRT, is a 3.8-m infrared telescope located on the summit of Mauna Kea, in Hawai'i. It began operations in 1979 and, at the time, it was the world's largest dedicated infrared telescope. It is still in use today, primarily to carry out a deep all-sky survey in the infrared, called the UKIRT Infrared Deep Sky Survey (UKIDSS). UKIRT is currently being funded by NASA and operated under a Scientific Cooperation Agreement among Lockheed Martin Advanced Technology Center, the University of Hawai'i, and the University of Arizona.

1983 Infrared Astronomical Satellite (IRAS)

The Infrared Astronomical Satellite (IRAS) was the first ever space-based infrared observatory to carry out a full-sky survey, covering 96% of the sky. Launched in 1983, it was a joint mission between the US, UK and the Netherlands, and lasted 10 months before its coolant ran out. It observed at wavelengths of 12, 25, 60 and 100 microns. IRAS detected 350,000 infrared sources, 70% of which were new discoveries. It also discovered wisps of warm dust, called infrared cirrus, across most of the sky.

1989 Cosmic Background Explorer (COBE)

COBE measured the cosmic background radiation of the Universe in infrared and microwave wavelengths across the whole sky, providing vital insights into the conditions of the early Universe. COBE discovered an exact match between the measured temperaturein all directions and the model (called a blackbody curve) predicted by Big Bang theory. COBE also discovered tiny fluctuations in the temperature of the cosmic background radiation, which track density variations in the early Universe. Astronomers believe that these variations led to the formation of galaxies.

1995 Palomar Testbed Interferometer (PTI)

The Palomar Testbed Interferometer connected three small telescopes so they could function as a single110m interferometer. The precision design was aided by working at an infrared wavelength of 2.2 microns, which is somewhat longer than visible light wavelengths. PTI allowed astronomers to precisely observe the positions, shapes, and sizes of stars. It was operated by NASA's Jet Propulsion Laboratory until 2008.

1995 Deep Near Infrared Survey of the Southern Sky (DENIS)

DENIS was a ground-based survey of the southern sky observing simultaneously at three near-infrared wavelengths (0.82, 1.25, and 2.15 microns). The Observations were made with the 1m ESO telescope at La Silla, Chile. Scientists and engineers from seven European countries and from Brazil collaborated on the survey.

1995 Infrared Telescope in Space (IRTS)

The Infrared Telescope in Space (IRTS) was a cryogenically cooled, small (15 cm mirror) telescope that flew from Mari::h to April 1995. During that time, it surveyed approximately 10% of the sky in many infrared wavelengths, from 1.4 microns to 700 microns. The IRTS was the first Japanese orbiting mission for infrared astronomy. The IRTS was just one of a number of experiments included on a spacecraft called the Space Flyer Unit (SFU), which was retrieved by the SpaceShuttle Endeavour on 20 January 1996.

1995 Infrared Space Observatory (ISO)

The Infrared Space Observatory (ISO) was a European Space Agency mission, launched in 1995. Thanks to improvements in infrared technology and detectors, ISO was thousands of times more sensitive than the first space-based infrared observatory, IRAS. With its 60 cm mirror, ISO observed in a wavelength range from 2.5 to 240 microns, until its coolant ran out in 1998. Among ISO's discoveries were the presence of water vapour in star-forming regions, the first detection of the earliest stages of star and planet formation, and Observations of one of the most luminous galaxies in the Universe.

1996 Midcourse Space Experiment (MSX)

MSX was a Ballistic Missile Defense Organization satellite experiment to map infrared sources in space. It was launched as a demonstration of the technology that would be required to identify and track ballistic missiles in flight, but MSX provided large amounts of astronomical data as well. It mapped the Galactic plane in infrared wavelengths, filling in the areas previously missed by IRAS and further studying areas identified as particularly bright and interesting. Calibration measurements for MSX were used to calibrate the later Spitzer Space Telescope and Akari missions.

1997 Two Micron All Sky Survey (2MASS)

2MASS was the first complete, ground-based, high-resolution, digital survey of the entire sky at any wavelength. The project used two telescopes, in the US and Chile, to gather data at 1.25, 1.65 and 2.17 microns. The resulting uniform, calibrated, near-infrared survey is widely used by astronomers.

Key science goals included probing the large-scale structure of the Galaxy, completing an accurate census of stars in our neighbourhood, and discovering faint brown dwarfs and active galactic nuclei.

1997 Hubble Space Telescope

While not primarily designed to be an infrared telescope, Hubble's view opened up to the infrared with the installation of the Near-lnfrared Camera and Multi-Object Spectrometer (NICMOS) during its second servicing mission in 1997. NICMOS allowed Hubble to peer through dust at infrared wavelengths of 0.8 to 2.5 microns. It contributed near-infrared data to Hubble's famous Ultra Deep Field, revealing galaxies too faint and distant to be seen by any previous telescope. NICMOS is not currently in operation, though it has been largely superseded in 2009 with the installation of the Wide Field Camera 3 (WFC3), which is sensitive to wavelengths up to 1.7 microns.

2003 Spitzer Space Telescope

Spitzer was, at its launch, the most sensitive infrared telescope ever put into space, with three instruments that took imaging and spectroscopic data between 3.6 and 160 microns. Spitzer is still operational today, taking images at 3.6 and 4.5 microns, observing everything from distant galaxies to comets and exoplanets. Spitzer has measured the mass of galaxies when the Universe was less than 10% of its current age, detected light from planets orbiting other stars, discovered water and hydrocarbons (the building blocks of life) araund other stars, and found a huge, previously-unseen ring around Saturn.

2006 Akari

Akari was Japan's second infrared space mission, and designed as a follow-up to IRAS. Its name means "light" in Japanese. It was launched in 2006, and observed more than 94% of the sky before its coolant ran out in 2007. Nevertheless, Observations continued in the near-infrared until an electrical failure in 2011. Akari's science results included the infrared detection of supernova remnants in a nearby galaxy, Observations of active star formation in spiral galaxies, and detections of mass lass from dying red giant stars in the Milky Way.

2009 Planck

Planck was space-observatory-based, operated by ESA from 2009 to 2013. It included NASA participation. Its Cosmic Microwave Back- ground (CMB) survey mission studied the afterglow of the Big Bang itself. It mapped the anisotropies of the cosmic microwave background (CMB) at microwave and infrared frequencies, with high sensitivity and small angular resolution. Planck had an order of magnitude better sensitivity and about 50 times the resolution of the original COBE mission. In 2013 the Planck team released the most detailed map of the CMB ever made. From the patterns of minute tluctuations in brightness seen across the entire sky, researchers have refined our understanding of the age of the universe (13.8 billion years) and its composition (4.9% ordinary matter, 26.8% dark matter, 68.3% dark energy).

2009 Wide-Field Infrared Survey Explorer (WISE)

WISE was a NASA mission designed to survey the entire sky in the mid-infrared. Taking over 1.5 million images of our Solar System, our Galaxy, and the Universe, it made the first discovery of some of the coldest stars in the Universe, called Y-dwarfs, and has discovered tens of thousands of new asteroids. WISE ran out of coolant in late 2010, but in September 2013 NASA reactivated the mission with the primary goal of scanning for near-Earth objects, or NEOs. Though the WISE mission had been doing asteroid searches before it entered hibernation, through a project called NEOWISE, that had not been its main purpose until now. The infrared detectors on NEOWISE make it an ideal platform for characterizing the properties of the small bodies in the Solar System, and will allow astronomers to make better determinations of their size and composition.

2009 Herschel Space Observatory

Hersehe! was an ESA mission with NASA participation. Observing at wavelengths from 55 to 672 microns, it was the only mission exclusively dedicated to the far infrared. It operated for 4 years before its coolant ran out in 2013. Carrying a single 3.5 m (11.5 ft) mirrar it was the largest infrared telescope ever launched. Hersehe! has revealed the structure of the early Universe, and how the earliest galaxies formed and evolved. In 2013, Hersehe! announced Observations of the youngest-ever protostars, capturing the earliest stages of star formation. Hersehe! also revealed the chemistry of the interstellar medium, and found vast new reservoirs of star-forming material in our galaxy.

2010 Stratospheric Observatory For Infrared Astronomy (SOFIA)

A joint project between NASA and the German Space Agency, SOFIA has a 2.5 m telescope mounted in the rear of a Boeing 747. SOFIA flies in the stratosphere, high enough to get above most of the infrared-blocking water vapour in the atmosphere. SOFIA's instruments are sensitive to optical, infrared and submillimetre light, and saw first light in May 2010. SOFIA studies planetary atmospheres and surfaces, the structure, evolution and composition of comets, the physics and chemistry of the interstellar medium, and the formation of stars.

2018 James Webb Space Telescope (JWST)

JWST, depicted overleaf, is the planned scientific successor to the Spitzer and Hubble Space Telescopes. JWST will be the biggest space telescope ever launched, with a 6.5 m mirrar that will give it unprecedented resolution and sensitivity. A large sunshield will keep it and its four science instruments below 50 K (-220 °C; -370 °F). JWST is designed to study the first galaxies that formed in the early Universe, and observe planet formation. It will also be vital for observing exoplanets and detecting atmospheric conditions that might be able to support life. JWST is currently due to launch in 2018.

2020 Euclid

Euclid is a European Space Agency (ESA) mission to study the geometry and nature of the universe. While it is specifically designed to Iook back to the early universe and probe the nature of dark energy, its observations will also be useful for exploring a wide range of astronomy topics. In January 2013, NASA joined the mission, and will provide 16 state-of the- art infrared detectors for the onboard science instruments. Euclid is being built by Thales Alenia Space, and construction started in July 2013. Launch is slated for sametime in 2020.

2020+ Wide-Field Infrared Survey Telescope (WFIRST-AFTA)

WFIRST is a planned NASA mission, intended to study some of the most fundamental questions in astronomy:

• Why is the expansion of the Universe accelerating, and what is the nature of the "dark energy" that is thought to be driving it?

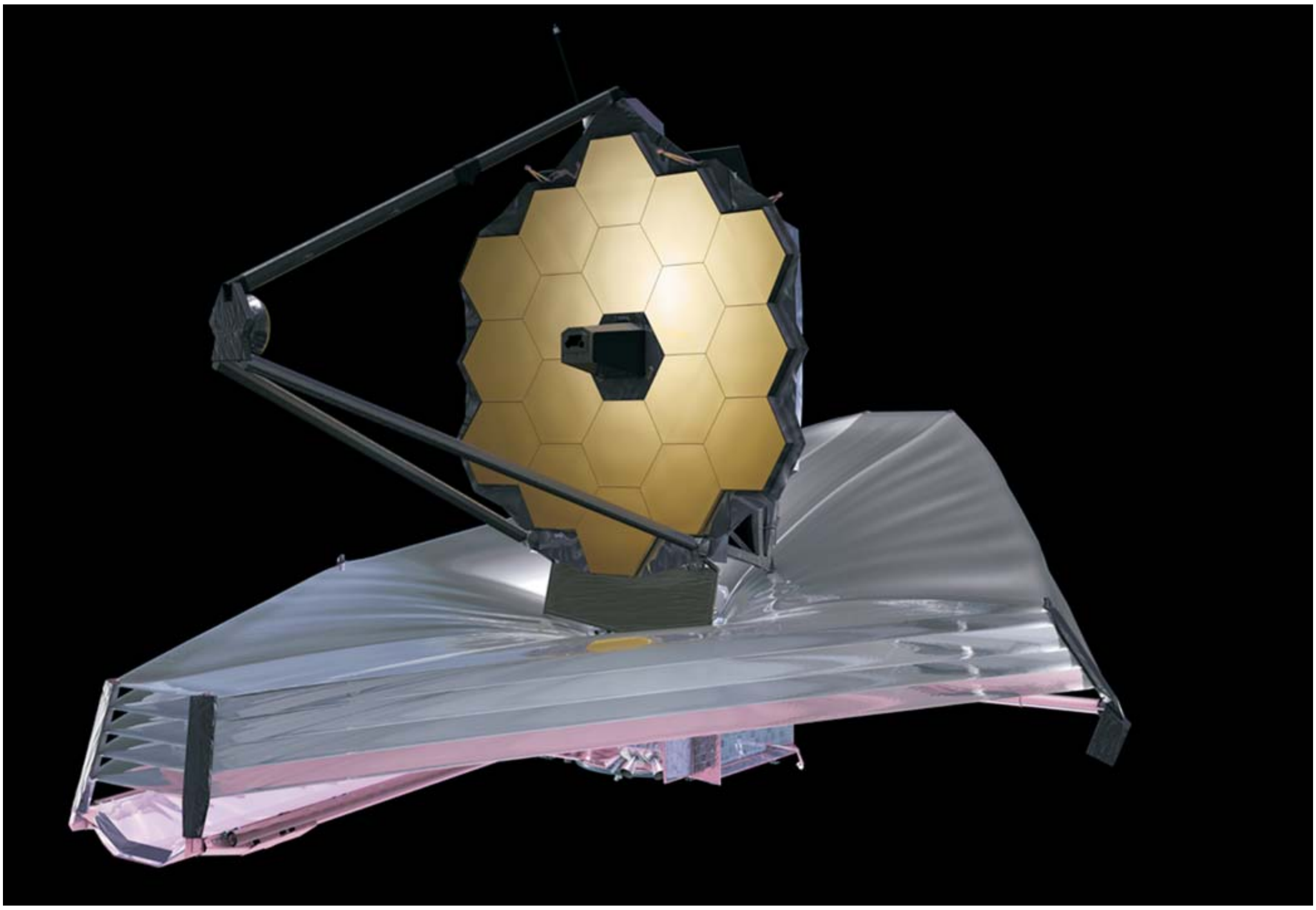
• Are there solar systems like ours out there, with planets like the Earth?

WFIRST is still in the planning stages, and will be launched sometime after 2020.

2022 Space Infrared Telescope for Cosmology & Astrophysics (SPICA)

SPICA is a proposed mission led by the Japanese Aerospace Exploration Agency (JAXA). It will provide infrared coverage at Ionger wavelengths than JWST. The spacecraft's main mission will be the study of star and planetary Formation. It will be able to detect stars forming in stellar nurseries in other galaxies, the first stages of planet Formation around other stars, and the end result- exoplanets.

The mission is currently planned for launch in 2022.



The James Webb Space Telescope

News in Thermology

21st Congress of the Polish Association of Thermology (PTA)

The following invitation was received from Prof Dr Anna Jung, vice-president of the EAT and president of Polish Association of Thermology

The XXI Meeting of the Polish Society of Medical Thermography combined with The European Association of Thermology will be held in Zakopane, Poland from 21st - 23rd April 2017

All are warmly invited to annual meeting at Zakopane.

Conference venue:
"HYRNY" Hotel, Pilsudskiego str. 20, Zakopane

Abstract should be sent to Prof Anna Jung
a.jung@spencer.com.pl,
latest by March 15th 2017,

Abstracts should show

Title (IN CAPITALS)

Authors (the name of the presenting author should be underlined)

Affilliation of all authors,

The abstract should structured in

Background

Aim of the study

Participants and Methods

Results (may include 1 diagram, 1 table and at maximum 2 thermal images)

Discussion and Conclusion

A maximum of 5 references can be included

All accepted abstracts will be published in Thermology international, Volume 27 (2017) Number 2 (May)

RESERVATION FOR ACCOMMODATION
before March 15th to ensure hotel reservation by
email:a.jung@spencer.com.pl

COSTS

Accommodation (2 nights) / meals, welcome dinner 120 E per person (participant, accompaning person) will be paid in cash/credit card on arrival in hotel reception.

SCIENTIFIC COMMITTEE

Dr.Kevin Howell Ph.D (UK)
Prof.Kurt Ammer MD,Ph.D (AUT)
Prof.Sillero-Quintana Manuel Ph.D
Dr.Aderito Seixas MSc. (POR)
Dr.Ricardo Vardasca Ph.D (POR)
Prof.Boguslaw Wiecek Ph.D,Eng (Poland)
Prof.Francis Ring Dsc (UK)
Prof.Anna Jung MD,Ph.D (Poland)
Prof.Antoni Nowakowski Ph.D,Eng (Poland)
Dr.Janusz Zuber MD,Ph.D (Poland)
Prof.Armand Cholewka Ph.D, Eng (Poland)

PROGRAMME AT A GLANCE.

21st April, Friday - 7 p.m.
Welcome Dinner (HYRNY Hotel)

22nd April, Saturday
9.00 - 11.00 Session I
11.00 - 11.20 Coffee break
11.20 -13.00 Session II
13.00 - 14.15 Lunch
14.30 - 16.00 Session III
16.00 - 16.15 Coffee break

16.15 - 18.00 EAT board meeting.

14th European Conference of Thermology 2018

EAT president Dr Kevin Howell reported substantial progress in preparing the 14th European Conference of Thermology 2018 at the National Physics Laboratory (NPL) in Teddington, England. The conference date 4th-7thJuly is now confirmed and a scientific committee was formed including EAT members and experts in metrology from UK, Germany and Slovenia.

A pre-conference thermograpy course will take place on July 4th at NPL's postgraduate teaching centre. The contents of the course are currently under review and an updated syllabus will be published on the EAT website and in this journal.

Also opportunites are explored to publish a "special issue" in one of the IOP based journals such as "Physiological measurement". The best presentations will be collected there after the conference, but submission to Thermology international is also possible.

2017

April 9th-13th 2017
Thermosense: Thermal Infrared Applications XXXIX in Anaheim, California, USA

Venue: Anaheim Convention Center

Conference Chair
Paolo Bison, Consiglio Nazionale delle Ricerche (Italy)

Conference Co-Chair
Douglas Burleigh, La Jolla Cove Consulting (United States)

This conference is no longer accepting submissions.

Thermal/infrared related papers are solicited in the areas listed below, and are also welcome in other areas.

Aerospace Applications
Automotive Industry
Building Applications
Calibration
Detection of Gas and Other Leaks
Environmental and Agricultural Monitoring
Fiber Optics for Infrared
Fire Analysis and Detection
Food Processing and Handling
Infrastructure
IR Image Fusion Applications
Manufacturing and Processing Industries
Infrared Nondestructive Testing (IR NDT) and Materials Evaluation
Medical

- health screening and diagnostics
- veterinary applications

Power Generation and Distribution
Research and Development
Remote Sensing and Security
Standards, Certifications and Guidelines

Further information:
https://spie.org/SIC/conferencedetails/thermosense

April 21st-23rd 2017
XXI National Congress of the Polish Association of Thermology in Zakopane, Poland

ABSTRACT DEADLINE March 15th 2015

Contact : a.jung@spencer.com.pl

INTERNATIONAL SCIENTIFIC COMMITTEE

Dr.Kevin Howell Ph.D (UK)
Prof.Kurt Ammer MD,Ph.D (AUT)
Prof.Sillero-Quintana Manuel Ph.D
Dr.Aderito Seixas MSc. (POR)
Dr.Ricardo Vardasca Ph.D (POR)
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Dr.Janusz Zuber MD,Ph.D (Poland)
Prof.Armand Cholewka Ph.D, Eng (Poland)

Registration by e-mail is required before March 15th to ensure hotel reservation.

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PROGRAMME AT A GLANCE.

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16.15 - 18.00 EAT board meeting

July 2nd-6th 2017
2nd Asian Conference on Quantitative InfraRed Thermography in Daejeon, Korea

Venue: Interciti Hotel, 92 Oncheon Ro, Yuseong-gu Daejeon, 34189, Rep of Korea

Important Dates
Abstrac submission deadline: February 28, 2017

Abstract acceptance notification: April 15, 2017

Full paper submission deadline: May 30, 2017

Furter information
www.qirtasia2017.com

Contact : Prof Wontae Kim
Div. of Mechanical & Automotive Engineering
Kongju National University, Cheonan,Chungnam, 30080, Rep of Korea, Email: kwr@kongju.ac.kr

September 27th - 29th, 2017
14th AITA 2017 (International Workshop on Advanced Infrared Technology and Applications) in Québec City, Canada

Conference venue: Université Laval

Information: AITA2017.gel.ulaval.ca

National Physical Laboratory

FIRST ANNOUNCEMENT

14th European Association of Thermology Congress

“Thermology in Medicine:

Clinical Thermometry and Thermal imaging”

4th – 7th July 2018

National Physical Laboratory, Teddington, London

United Kingdom

LONDON 2018

XIV E.A.T. Congress, 4-7 July

National Physical Laboratory

www.europeanthermology.com

The EAT and the National Physical Laboratory are delighted to invite you to participate in the XIV EAT Congress in Teddington, London, United Kingdom from 4th to 7th July 2018.

The European Association of Thermology exists to promote, support and disseminate research in thermometry and thermal imaging in the fields of human and veterinary medicine and biology. We do this through our peer-reviewed journal Thermology International, regional seminars around Europe, and our flagship Congress, which takes place every three years.

Following on from the most recent meetings in Porto (2012) and Madrid (2015), the Congress heads back to northern Europe for 2018 to the National Physical Laboratory (NPL) in the United Kingdom.

The EAT Board looks forward to welcoming you to NPL's world class conference facilities in the summer of 2018.

Dr. Kevin Howell
EAT President
Chair, 2018 EAT Congress Organising Committee

VENUE.

The National Physical Laboratory (NPL) is the United Kingdom's National Measurement Institute and is located in Teddington, south west London, approximately 30 minutes by taxi from Heathrow Airport and a 30 minute train journey from London Waterloo. www.npl.co.uk/location.

ORGANISING COMMITTEE.

Kevin Howell (GBR), Chair
Kurt Ammer (AUT)
Roger Hughes (GBR, NPL)
Anna Jung (POL)
Graham Machin (GBR, NPL)
Francis Ring (GBR)
Adérito Seixas (POR)
Rob Simpson (GBR, NPL)
Manuel Sillero-Quintana (SPA)
Ricardo Vardasca (POR)

INTERNATIONAL SCIENTIFIC COMMITTEE.

John Allen (GBR)
Kurt Ammer (AUT)
Damiano Formenti (ITA)
Kevin Howell (GBR)
Anna Jung (POL)
Graham Machin (GBR)
James Mercer (NOR)
David Pascoe (USA)
Igor Pušnik (SLO)
Francis Ring (GBR)
Manuel Sillero-Quintana (SPA)
Adérito Seixas (POR)
Maria Soroko (POL)
Rob Simpson (GBR)
Dieter Taubert (GER)
Rod Thomas (GBR)
Ricardo Vardasca (POR)

KEY DATES.

Abstract submission will open online on 31st July 2017, and authors will be notified of acceptance for oral or poster presentation by 29th January 2018.

December 2016. Publication of the First Announcement.
July 2017. Publication of the "Call for Abstracts" document.
31st July 2017. Opening of abstract submission and registration.
29th November 2017. Abstract submission deadline
29th January 2018. Acceptance notification to authors.
26th February 2018. End of Early Registration and deadline for registration of presenting authors.

LONDON 2018
XIV E.A.T. Congress, 4-7 July NPL

XIV EAT CONGRESS 4th – 7th July 2018, NPL.

REGISTRATION FEES (*)

	Early Registration (Until 26 FEB 2018)	Late Registration (After 26 FEB 2018)
EAT MEMBER	£200	£250
Non-Member	£250	£300
Student (**)	£170	£220

(*) Further information about the registration process will be provided in the "Call for abstracts" document. Registration includes access to all congress sessions, congress lunch and coffee breaks, the Congress Dinner, and a guided visit to the historic Hampton Court Palace on 7th July.

ACCOMMODATION

There are a number of hotels within walking distance of the National Physical Laboratory and Teddington railway station, and even more choice within a 15 –minute radius by train, taxi or bus. Further information about local hotels can be found at http://www.npl.co.uk/contact-us/local-hotels. Early booking in 2018 is advisable!

ACCOMPANYING PERSONS

With central London just 30 minutes away by rail, Teddington is an excellent base for accompanying persons to enjoy the capital city of the UK without the need for an organised tour. All accompanying persons will be invited to join the Congress Dinner and social programme upon payment of the appropriate fee.