Radiation Safety Institute of Canada
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Lunch, Learn, & Dance
Wellness Webinars

April 8, 2021

EMF and WiFi

Followed by Araguacu Latin Dance Company

Good Science in Plain Language®

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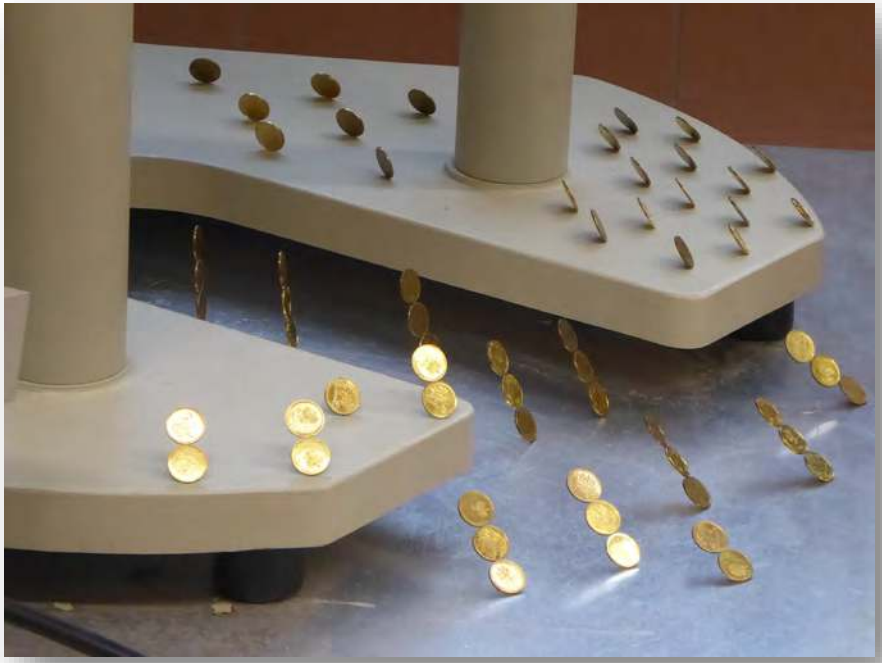
Webinar Functionality

- Audio and video
  - Will be from the presenters only
  - Use computer or telephone (call in)
  - Computer seems to give the best sound quality
- Use the “Chat” feature to enter comments
- Use the “Questions” feature to ask questions
- Posted on webinar page
  - Video, Q&A answers, copy of the slides
- Follow up email will be sent
  - Topics covered, time of attendance
- It may be possible to change your Zoom view if the controls are hiding the closed captioning.

Outline

- What is EMF?
  - Electricity
  - Magnetism
  - Electromagnetic radiation
- Research and Regulation
  - ITU
  - ICNIRP
  - IARC Monographs
  - WHO
  - IEEE
  - Health Canada
- Sources, Health Effects, & Limits
  - Static Electric
  - Static Magnetic
  - Low Frequency
  - RF EMF
    - WiFi



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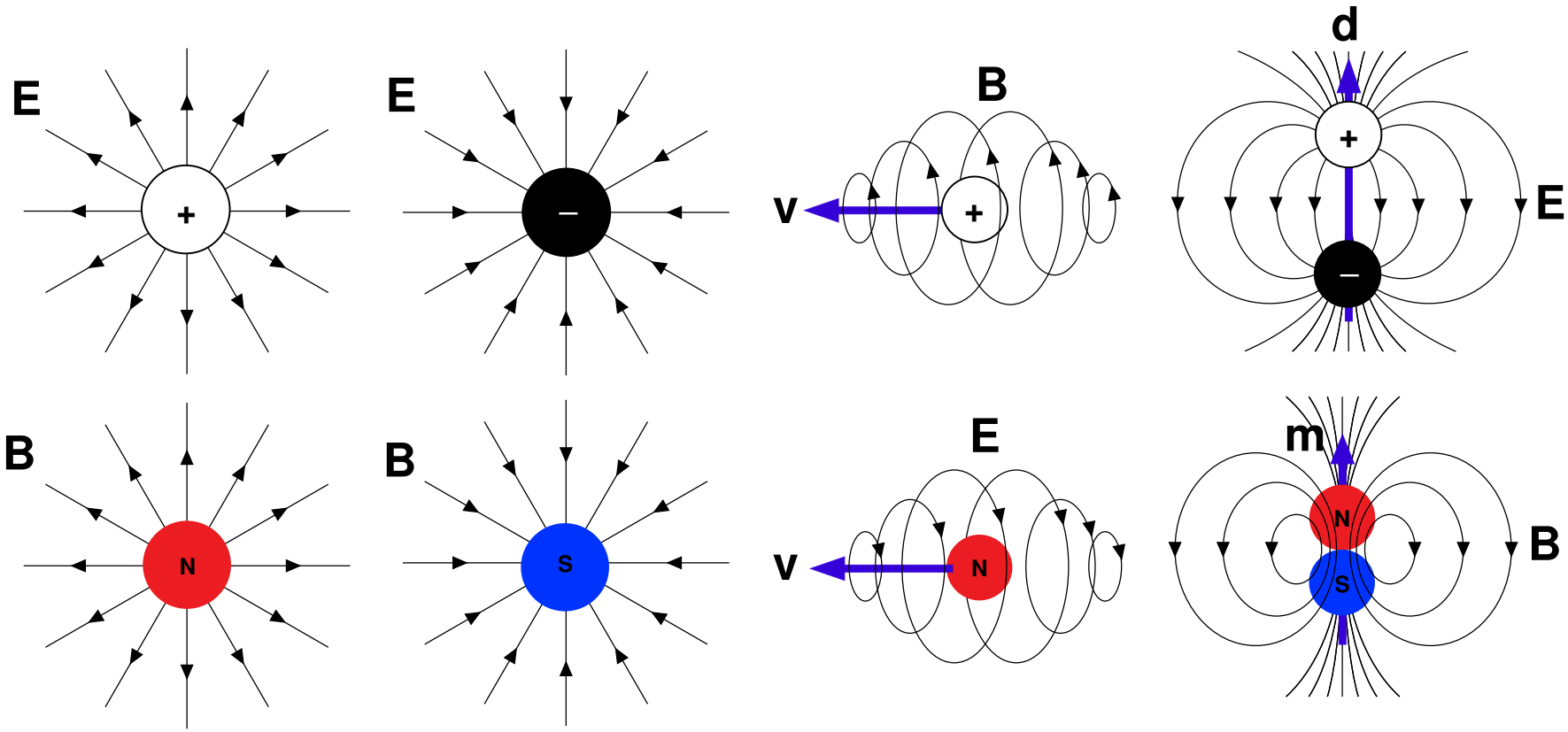
What is EMF?



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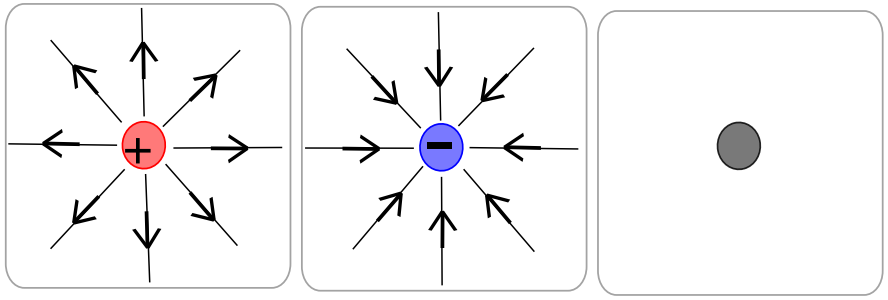
What Is Electricity?



- Characteristic of matter
- Electric charges create electric fields
- Fields have different shapes
  - Unit of electric field V/m
- Flow of electrons is called current
  - Symbol: I
  - Unit: ampere (A)

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Electric Field Near a Wire

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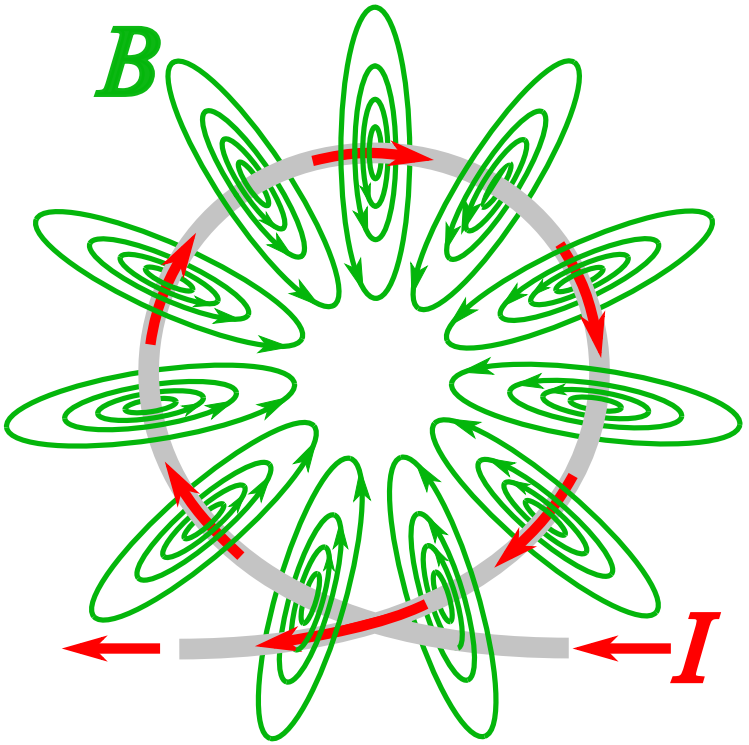
What Is Magnetism?

- Characteristic of matter
- No magnetic monopole
- Magnetic fields creation
  - Magnets
  - Electric current
  - Changing electric field
- Perpendicular to current flow
- Unit
  - gauss (G)
  - tesla (T)
- Exert magnetic forces



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Magnetic Field in a Wire

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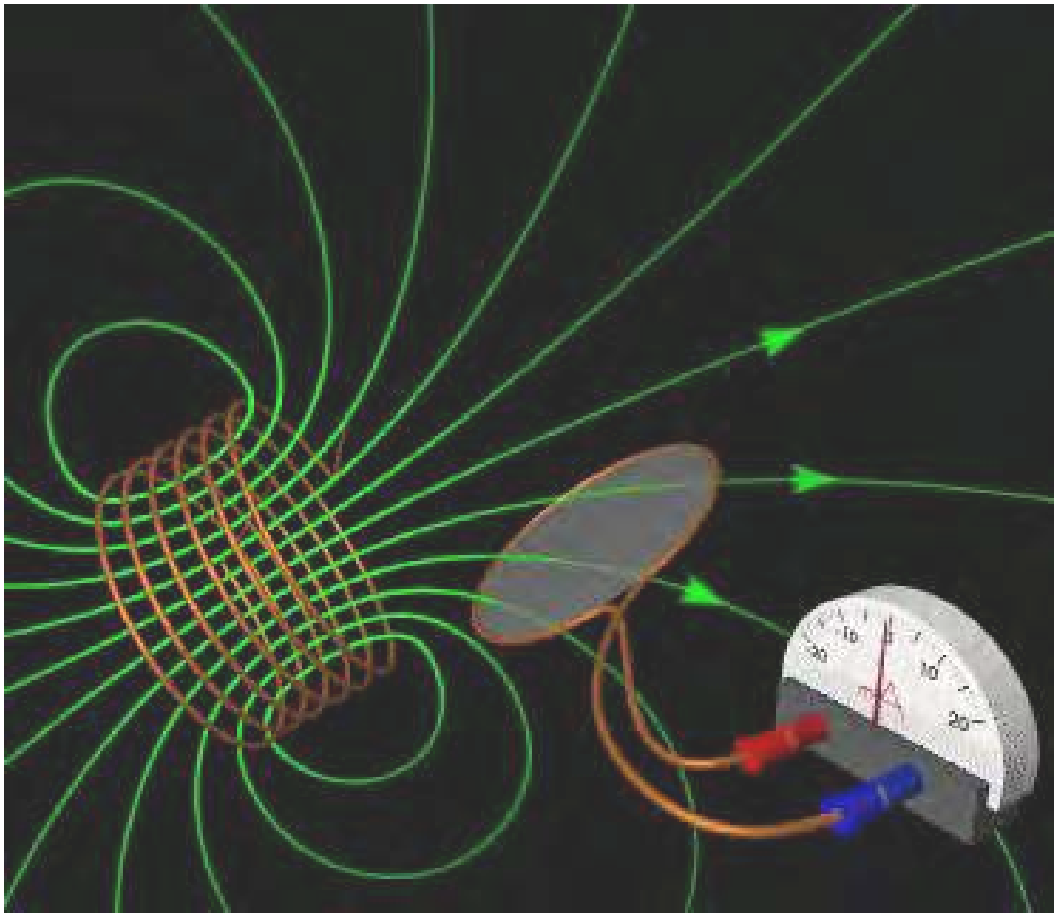
Electromagnetism



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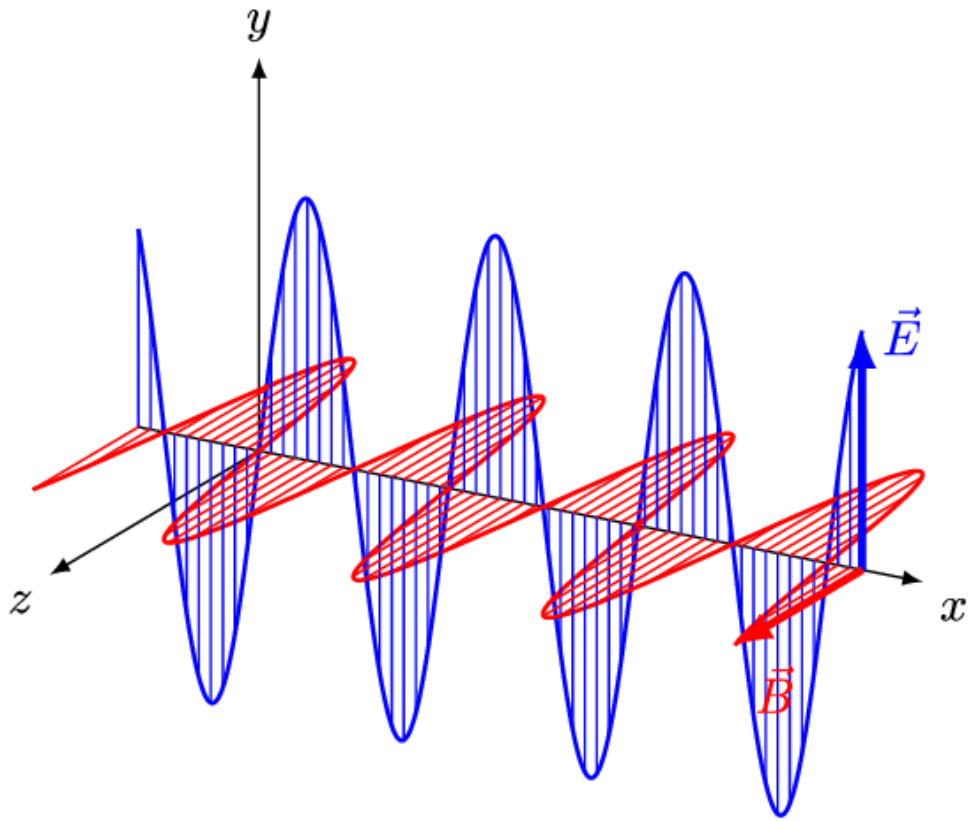
Electromagnetic Radiation



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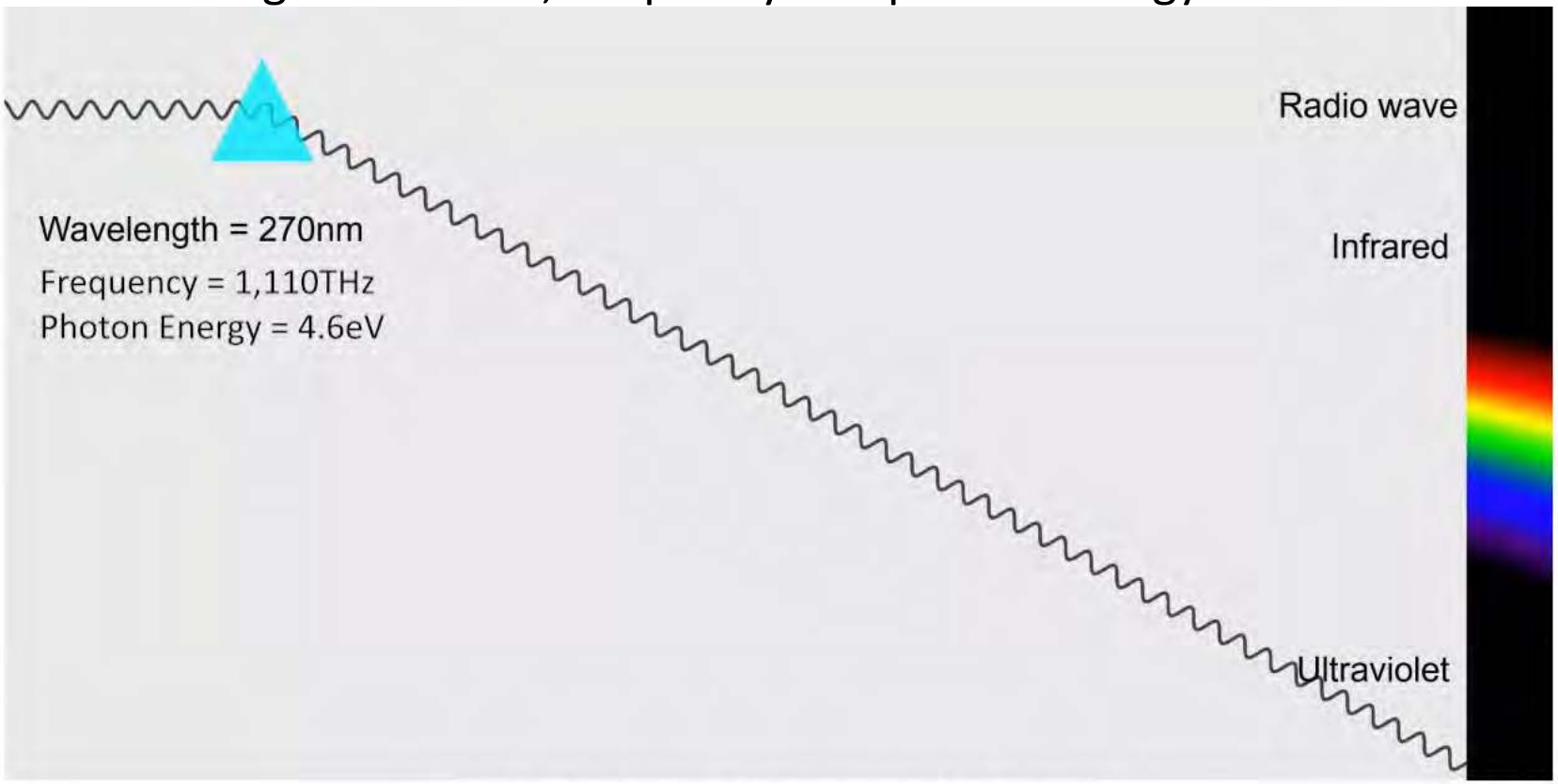
Frequency, Wavelength, Photon Energy

- As wavelength increases, frequency and photon energy decreases.



Created with “Electromagnetic Waves around of Visible Rays” simulation
by Dongloon, located at JavaLab.org

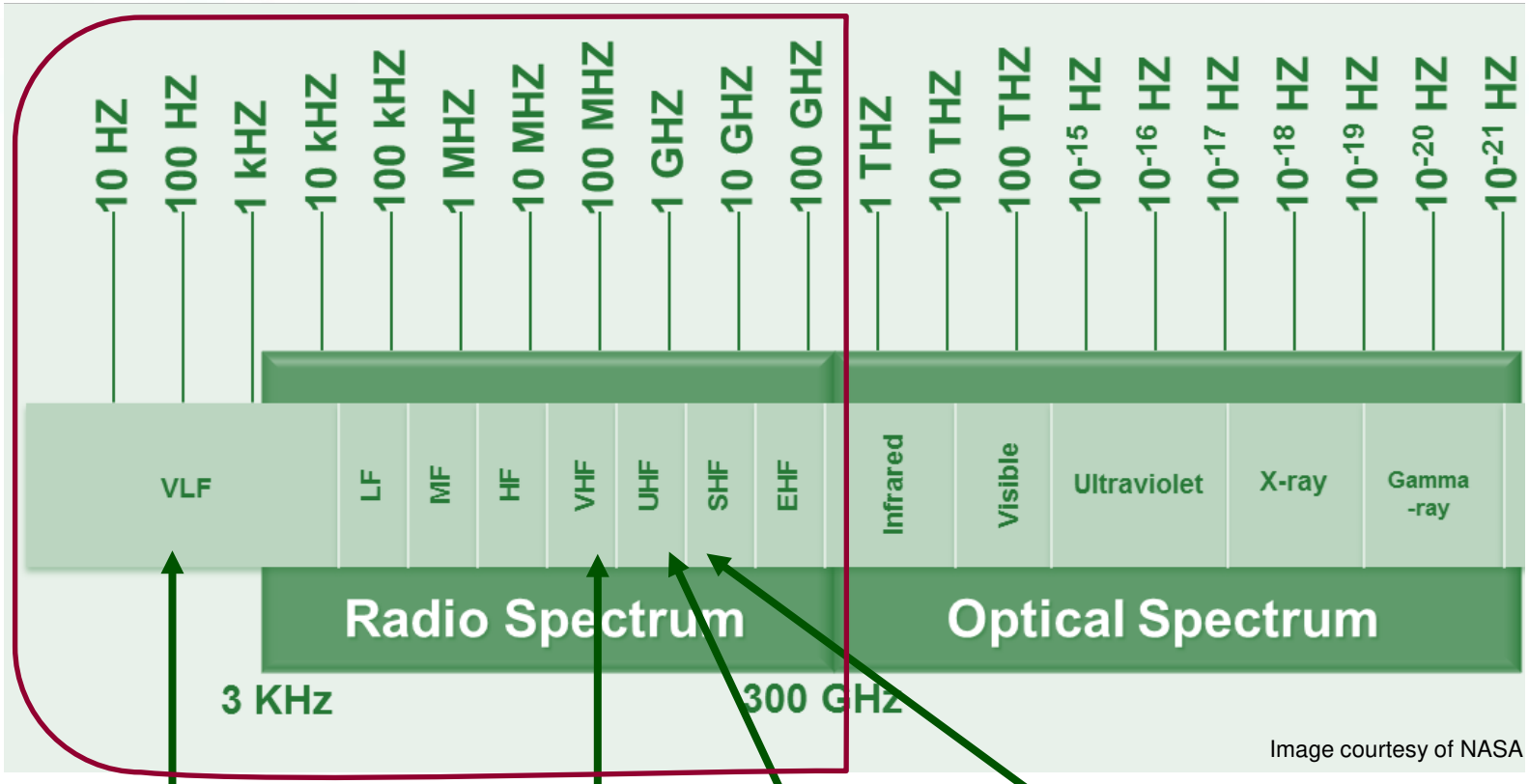


Image courtesy of NASA

60 Hz Power Frequency

76 MHz – 108 MHz FM Radio

700 MHz Band Cell Services

2.45 GHz Microwave Oven

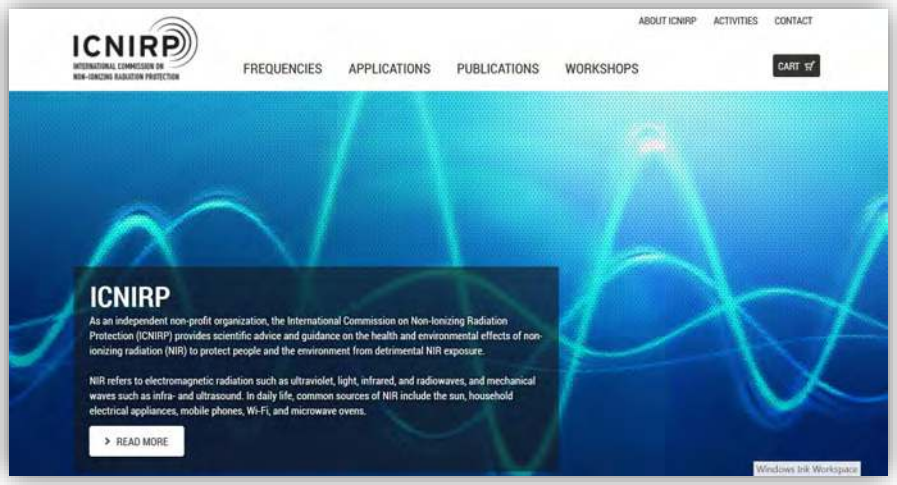
ITU

- United Nations Special Agency
- Allocates Radiofrequency
  - Member States

Radiofrequency Spectrum Bands

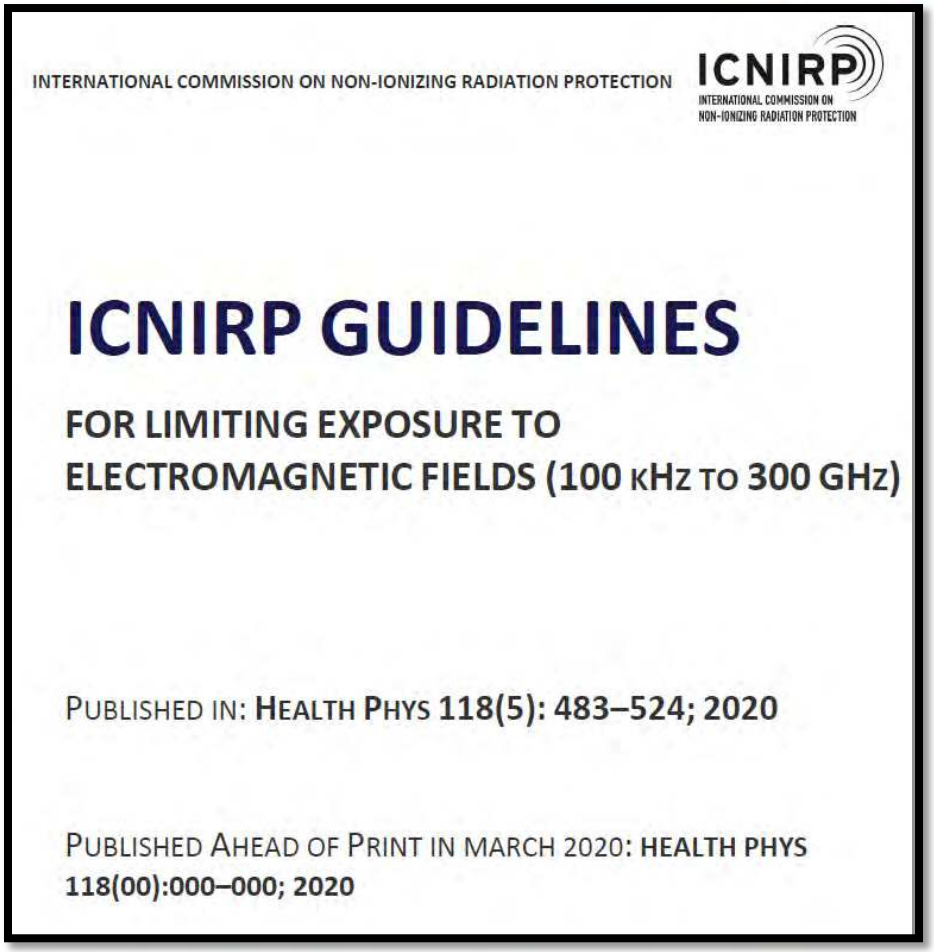
Frequency (MHz)	Band	Description
0 – 0.000 03	SELF	Sub-extremely low frequency
0.000 03 – 0.000 3	ELF	Extremely low frequency
0.000 3 – 0.003	VF	Voice frequency
0.003 – 0.03	VLF	Very low frequency
0.03 – 0.3	LF	Low frequency
0.3 – 3	MF	Medium frequency
3 – 30	HF	High frequency
30 – 300	VHF	Very high frequency
300 – 3 000	UHF	Ultra high frequency
3 000 – 30 000	SHF	Super high frequency
30 000 – 300 000	EHF	Extremely high frequency
300 000 – 3 000 000	SEHF	Supra-extremely high frequency

ICNIRP

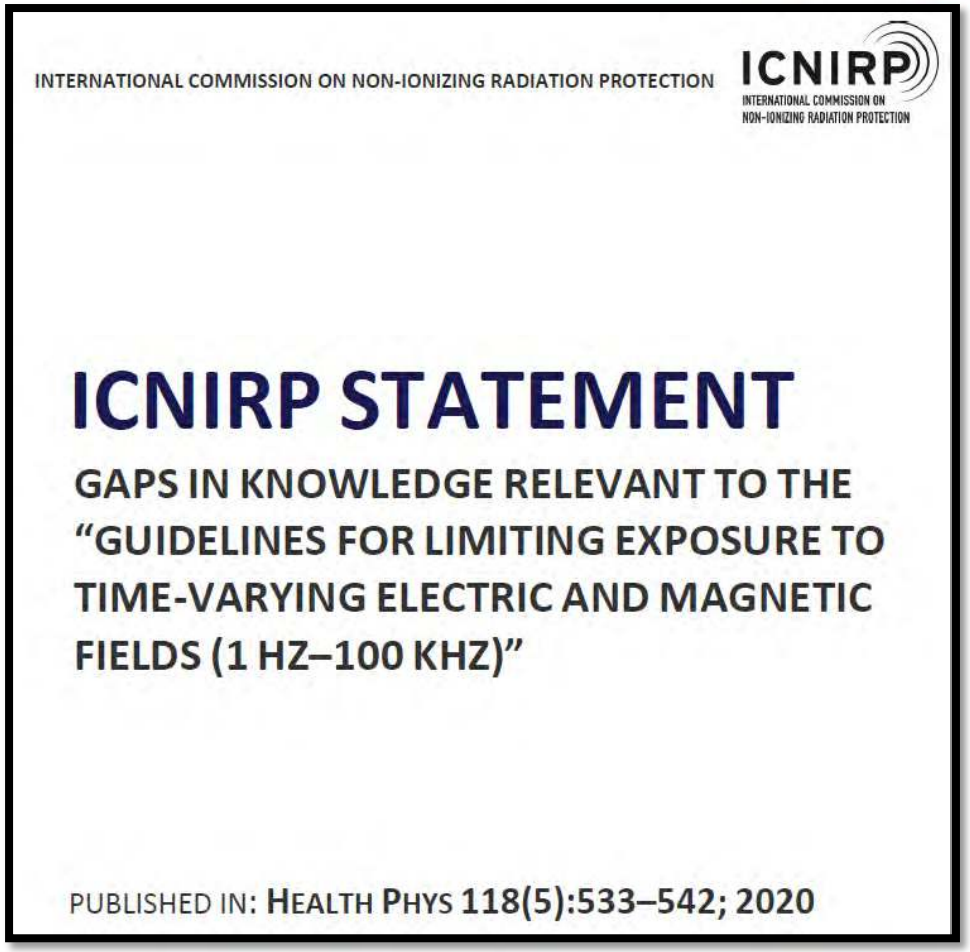


- Not-for-profit based in Germany
- Internationally-recognized
- Non-ionizing radiation
- Science-based
- Information is free to public

ICNIRP Guidelines



Gaps in Knowledge



Gaps in Knowledge

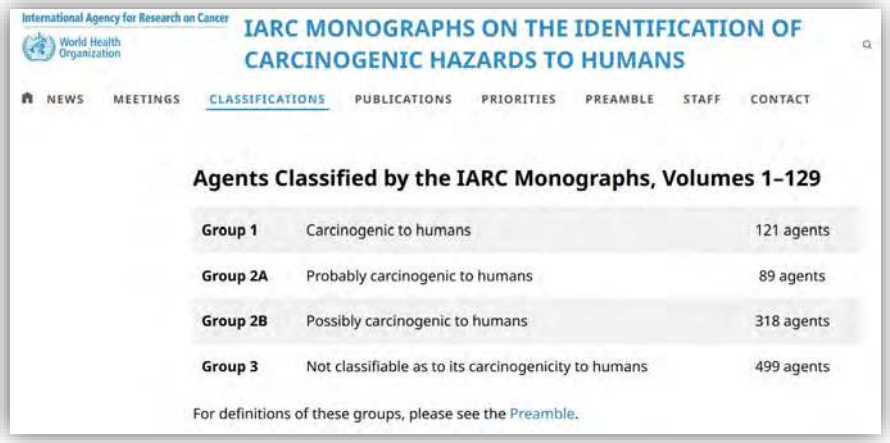
Topic	Robustness	Consistency	Comments
Pain Perception	In general, limited and heterogeneous human research showing no effect for most endpoints. Contact current literature is limited to 1 study.	Inconsistent results between human and animal data in general. Contact current literature on pain consists of only one single study.	Data gap only identified in relation to contact currents. Further studies on contact currents are therefore recommended.
Neurodegenerative Disease	Research in this area is not robust.	Inconsistent results.	Further epidemiological and experimental studies on Alzheimer's disease and ALS would be useful.
Childhood Leukemia	Limited research using adequate animal models is not robust. Substantial number of epidemiological studies of ELF-MF and childhood leukemia.	Generally no support for cancer induction or promotion from animal models. Consistent results from epidemiological studies on childhood leukemia indicate increased risk, but weaker findings over time.	Further studies on mechanisms and biological data from childhood leukemia experimental models are recommended. No further epidemiological studies unless a biologically based hypothesis can be formulated.

Gaps in Knowledge

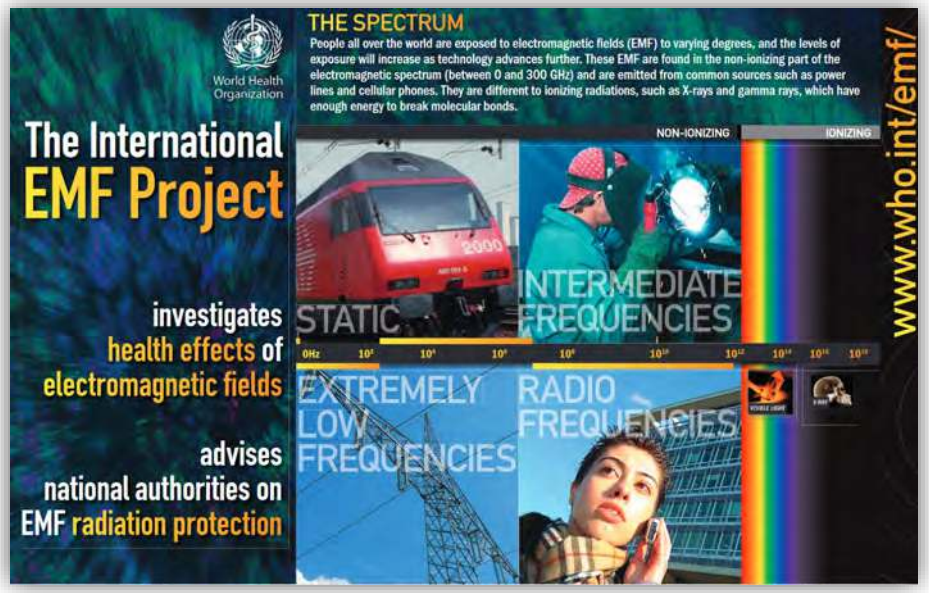
Topic	Robustness	Consistency	Comments
Neural Network Firing Patterns	Well established phenomena.	Wide range of estimates of sensitivities.	Uncertainties in precise mechanism and derivation of tissue E-fields implies that actual thresholds could be lower (or higher) than current levels.
Free Radical Lifetimes	Effect of magnetic fields on free radical lifetimes well-established, but at higher field values than reference levels.	The radical par mechanism is the only physically plausible way in which biological systems may be sensitive to low intensity magnetic fields. Observations are far from sufficient to explain predict [sic] health effects an to require consideration of guidelines.	Ongoing research outcomes may motivate revision of conclusions regarding relevance to standard-setting.
Dosimetry & Modelling	A certain number of reports on MF exposure, but not robust in some cases. Limited research on ELF exposure, contact current and non-sinusoidal wave exposures.	Some inter-comparison between models, but more needed. More critical examination of assumptions made required.	Considerable gaps remain (see text for specific details)

IARC Monographs

- International Agency for Research on Cancer
- Monographs on Carcinogenic Hazards
  - Group 1: Carcinogenic to humans (121)
  - Group 2A: Probably carcinogenic to humans (89)
  - Group 2B: Possibly carcinogenic to humans (318)
  - Group 3: Not classifiable as to its carcinogenicity to humans (499)



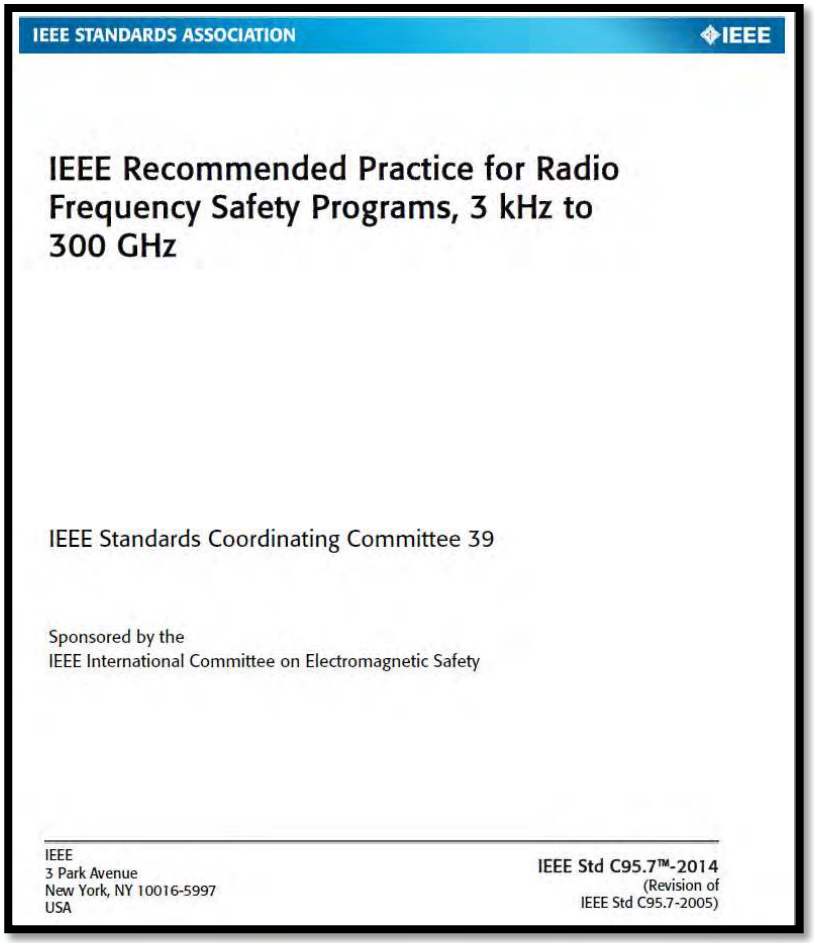
World Health Organization



- Information as Health Topic
- EMF Project
  - Response to concerns
  - Assess scientific literature
  - Identify gaps
  - Encourage focused research
  - Incorporate research results into monographs
  - Facilitate the development of standards
  - Provide information on management to national and other authorities
  - Provide advice about hazards

IEEE

- World's largest technical professional organization
- Reputable source
- Numerous standards available
  - Free and paid service


IEEE STANDARDS ASSOCIATION IEEE

IEEE Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz

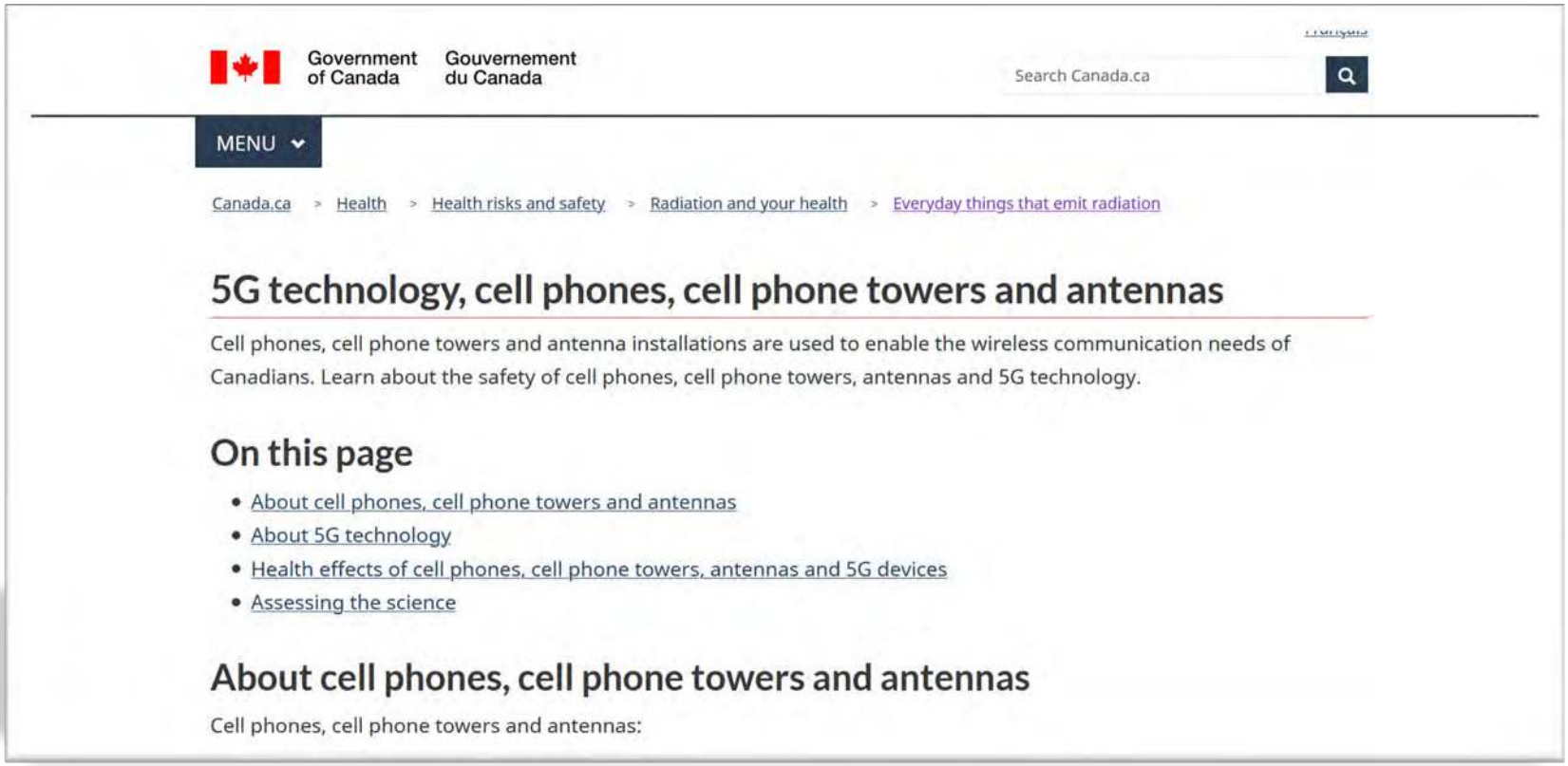
IEEE Standards Coordinating Committee 39

Sponsored by the
IEEE International Committee on Electromagnetic Safety

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std C95.7™-2014
(Revision of
IEEE Std C95.7-2005)

Health Canada



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MENU

Canada.ca > Health > Health risks and safety > Radiation and your health > Everyday things that emit radiation

5G technology, cell phones, cell phone towers and antennas

Cell phones, cell phone towers and antenna installations are used to enable the wireless communication needs of Canadians. Learn about the safety of cell phones, cell phone towers, antennas and 5G technology.

On this page

- About cell phones, cell phone towers and antennas
- About 5G technology
- Health effects of cell phones, cell phone towers, antennas and 5G devices
- Assessing the science

About cell phones, cell phone towers and antennas

Cell phones, cell phone towers and antennas:

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Biological vs. Health Effects

Biological Effect

- Biological system
- Change in response to a stimulus

Health Effect

- A type of biological effect
- Causes detectable impairment of health

Static Electric

- Do not change in intensity or direction over time
- Created by
  - Static charges
  - Constant DC current
- Examples
  - Static electricity in hair
  - DC transmission lines
  - Cathode ray tube (CRT) TVs and monitors
  - Natural electric field of Earth

Ken Bosma from Green Valley, Arizona, USA, CC BY 2.0

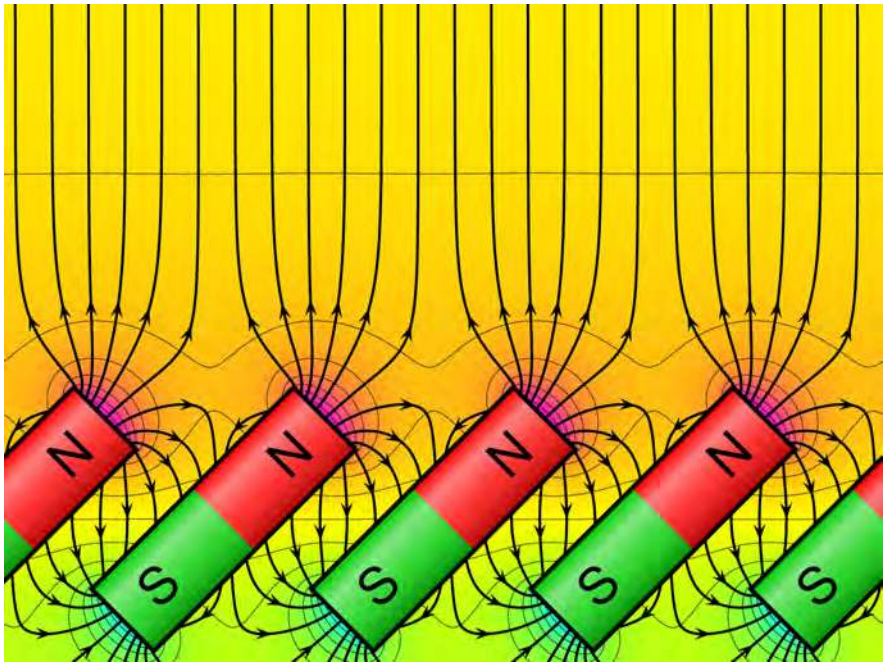
Static Electric: Health Effects

- Do not penetrate the body
- Surface electric charge
- Spark discharges
  - Stress
- Can charge particles in the air
  - May raise exposure to air pollution, but unlikely
- Large static buildup could lead to a strong discharge which could burn or interrupt heart
  - Lightning or large static discharge

Static Electric: Exposure Limits

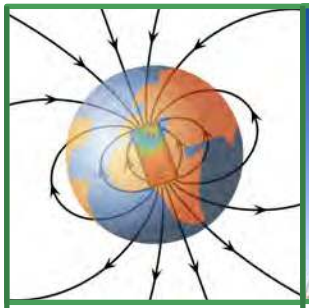
- Can shield or ground to remove excess static electricity
- Minimize exposure to microshocks
  - Lower stress
- Do not work outdoors or in areas if there is a chance of lightning or large static electric charge buildup

Static Magnetic



- Do not change in intensity or direction over time
- Not able to shield
  - But can bend the field (magnetic shielding)
- Created by
  - Magnets
  - Moving charges
  - Changing electric fields

Static Magnetic: Source Examples



Earth's Magnetic Field

- ~50 µT
- Range ~30 – 70 µT

High DC Transmission Lines

- 20 µT

Fast Passenger Trains

- Based on magnetic levitation
- Inside cabin below 100 µT
- Localized field near floor can be several mT

Household magnets

- Local fields in excess of 0.5 mT

MRI

- 0.15 to 3 T
- fMRI research up to 10T

Industrial uses

- Few mT to 10s of mT.

Image attributions at the end of the deck.

Static Magnetic: Health Effects

- Biological effects
  - Will affect movement electrically charged particles and cells in the blood
  - Strong fields can give transient vertigo and nausea
  - Not health effects, per se, but annoying or upsetting
- No evidence for adverse health effects for exposures to fields up to 8T
  - Except possibly hand-eye coordination and visual contrast

Static Magnetic: Exposure Limits

Exposure Characteristics	Magnetic Flux Density Limits of Exposure
Occupational	
Exposure of head and of trunk	2T
Exposure of limbs	8T
General Public	
Exposure to any part of the body	400 mT

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EMF Operating Frequency

Equipment	Frequency	Description	Band
Appliances	60 Hz	Extremely low frequency	ELF
Induction heaters	3 MHz	Medium frequency	MF
RF heat sealers	30 MHz	High frequency	HF
FM radio	300 MHz	Very high frequency	VHF
Wi-Fi	2.4 GHz	Ultra high frequency	UHF

Low Frequency EMF: Sources

Equipment	Mag field (mG)
Copy machines	20
Fluorescent lights	6

Source: US EPA, 1992

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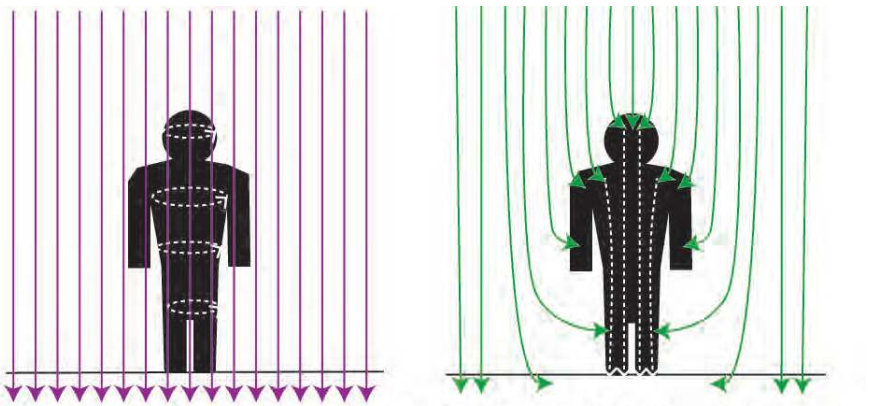
Low Frequency EMF: Health Effects



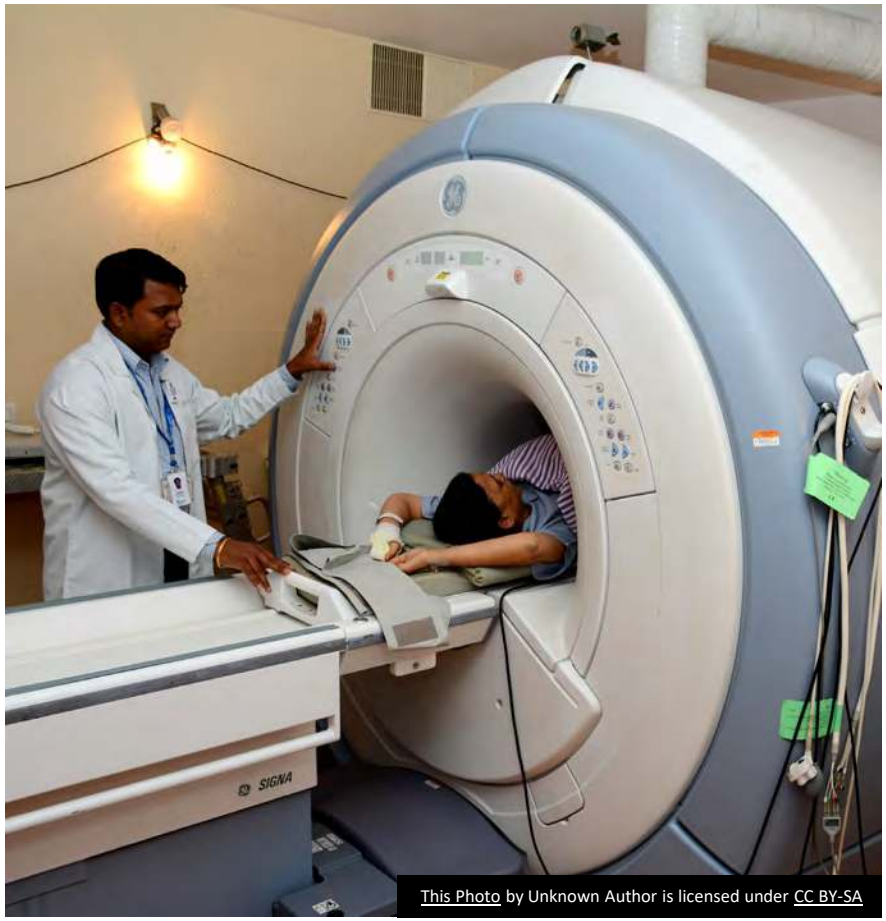
Magnetic field lines are in purple; electric field lines in green; and induced currents are in dashed white.

- Induced currents
- Above threshold reversible effects
  - Faint light flickering in peripheral vision
  - Electric charge effects on the skin
  - Tingling sensation due to stimulation of nerves and muscles
- Higher levels
  - Irreversible cardio-vascular effects
  - Tissue burns
- Overall research has not shown long-term low-level LF exposure has detrimental health effects

Low Frequency EMF: Exposure Limits

	Exposure Characteristic	Frequency Range	Internal Electric Field (V/m)
Occupational Exposure	CNS tissue of the head	1 – 10 Hz	0.5/f
		10 – 25 Hz	0.05
		24 – 400 Hz	0.002 f
		400 Hz – 3 kHz	0.8
		3 kHz – 10 MHz	0.00027 f
	All tissues of head and body	1 – 3 Hz	0.8
		3 Khz – 10 MHz	0.00027 f
General Public Exposure	CNS tissue of the head	1 – 10 Hz	0.1/f
		10 – 25 Hz	0.01
		24 – 1000 Hz	0.0004 f
		1000 Hz – 3 kHz	0.4
		3 kHz – 10 MHz	0.000135 f
	All tissues of head and body	1 – 3 Hz	0.4
		3 Khz – 10 MHz	0.000135 f

Radiofrequency EMF



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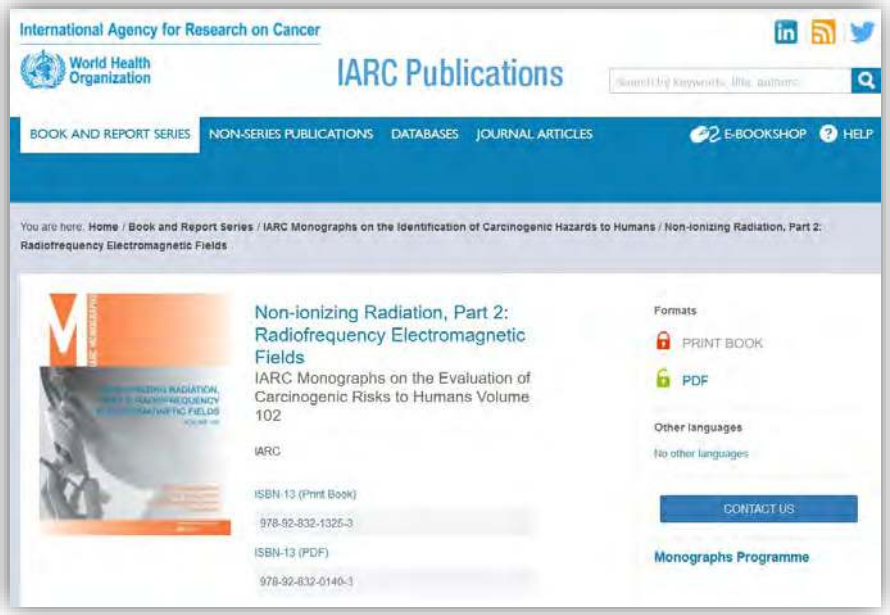
- 100 kHz – 300 GHz
- Unit: W/m^2 or W/kg
- Medical
- Heating
- Wireless power transfer
- Industrial
- Communications

Telecommunications Industry

- Towers and antennas
- Radar systems
- Pagers
- Cordless telephones
- Satellite communications
- Radio communications
- Mobile phones and base stations

Radiofrequency EMF: Health Concerns

- Decades of research
- Heating of exposed tissue
  - Only substantiated effect
- Above a threshold, heatstroke and burns
- Extensively studied
- Below a threshold, unlikely any adverse health effects.
- ICNIRP uses reduction factors in exposure guidelines to account for uncertainty
- IARC Monograph Class 2B



Radiofrequency EMF: Exposure Limits

Table 3. Basic restrictions for electromagnetic field exposure from 100 kHz to 300 GHz, for integrating intervals >0 to <6 min.[a]

Exposure scenario	Frequency range	Local Head/Torso SA (kJ kg^{-1})	Local Limb SA (kJ kg^{-1})	Local U_{ab} (kJ m^{-2})
Occupational	100 kHz to 400 MHz	NA	NA	NA
	>400 MHz to 6 GHz	$3.6[0.05+0.95(t/360)^{0.5}]$	$7.2[0.025+0.975(t/360)^{0.5}]$	NA
	>6 to 300 GHz	NA	NA	$36[0.05+0.95(t/360)^{0.5}]$
General public	100 kHz to 400 MHz	NA	NA	NA
	>400 MHz to 6 GHz	$0.72[0.05+0.95(t/360)^{0.5}]$	$1.44[0.025+0.975(t/360)^{0.5}]$	NA
	>6 to 300 GHz	NA	NA	$7.2[0.05+0.95(t/360)^{0.5}]$

[a]Note:

1. "NA" signifies "not applicable" and does not need to be taken into account when determining compliance.
2. t is time in seconds, and restrictions must be satisfied for all values of t between >0 and <360 s, regardless of the temporal characteristics of the exposure itself.
3. Local SA is to be averaged over a 10-g cubic mass.
4. Local U_{ab} is to be averaged over a square 4-cm^2 surface area of the body. Above 30 GHz, an additional constraint is imposed, such that exposure averaged over a square 1-cm^2 surface area of the body is restricted to $72[0.025+0.975(t/360)^{0.5}]$ for occupational and $14.4[0.025+0.975(t/360)^{0.5}]$ for general public exposure.
5. Exposure from any pulse, group of pulses, or subgroup of pulses in a train, as well as from the summation of exposures (including non-pulsed EMFs), delivered in t s, must not exceed these levels.

Wifi

Table 1 Limits for general public (lower tier) in ICNIRP and IEEE

	Frequency range	Incident power density	Averaging area	Averaging time
ICNIRP (1998)	2-10 GHz	10 W/m²		6 min
	10-300 GHz	10 W/m² (200 W/m²)	20 cm² (1 cm²)	Decrease from 6 min to 10 s
IEEE (2005)	Whole Body Exposure			
	5-30 GHz	10 W/m²	100 λ^2 *	Decrease from 30 min to 5 min
	30-100 GHz	10 W/m²	100 cm²	Decrease from 5 min to 2.8 min
	100-300 GHz	Increase from 10 W/m² to 100 W/m²	100 cm²	Decrease from 2.8 min to 10 s
	Local Exposure			
	3-30 GHz	Increase from 40 W/m² to 200 W/m²	peak	Decrease from 30 min to 5 min
	30-300 GHz	200 W/m²		Decrease from 5 min to 10 s
ICNIRP (2019)	Whole Body Exposure			
	2-300 GHz	10 W/m²		30 min
	Local Exposure			
	6-300 GHz	Decrease from 40 W/m² to 20 W/m²	4 cm²	6 min
	30-300 GHz	Decrease from 60 W/m² to 40 W/m²	1 cm²	6 min
IEEE C95.1 (2019)	Whole Body Exposure			
	2-300 GHz	10 W/m²		30 min
	Local Exposure			
	6-300 GHz	Decrease from 40 W/m² to 20 W/m²	4 cm²	6 min
	30-300 GHz	Decrease from 60 W/m² to 40 W/m²	1 cm²	6 min

* λ means the free space wavelength

From 5G Communications Systems and Radiofrequency Exposure Limits
IEEE Future Networks Tech Focus, Volume 3, Issue 2, September 2019

Radiation Safety Institute of Canada

- The Radiation Safety Institute of Canada is an independent, not-for-profit organization specializing in radiation safety.

- For further information on all types of radiation contact us at:

1-800-263-5803

info@radiationsafety.ca

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Slide 29 Image Attributions

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