Astronomy beyond the visible

Astronomia zaidi ya inayoonekana

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Goals

Malengo

- **Show phenomena beyond the visible, e.g. the electromagnetic energy emitted by celestial bodies, but undetectable by the human eye.**
- Onyesha matukio zaidi ya yanayoonekana, k.m. nishati ya sumakuumeme inayotolewa na miili ya mbinguni, lakini isiyoweza kutambulika kwa jicho la mwanadamu.
- **Perform several simple experiments for determining the existence of emission in the wavelength regions of radio waves, infrared, ultraviolet, microwave and X-ray.**
- Fanya majaribio kadhaa rahisi kwa ajili ya kuamua kuwepo kwa chafu katika mikoa ya urefu wa mawimbi ya redio, infrared, ultraviolet, microwave na X-ray.

Presentation
Wasilisho

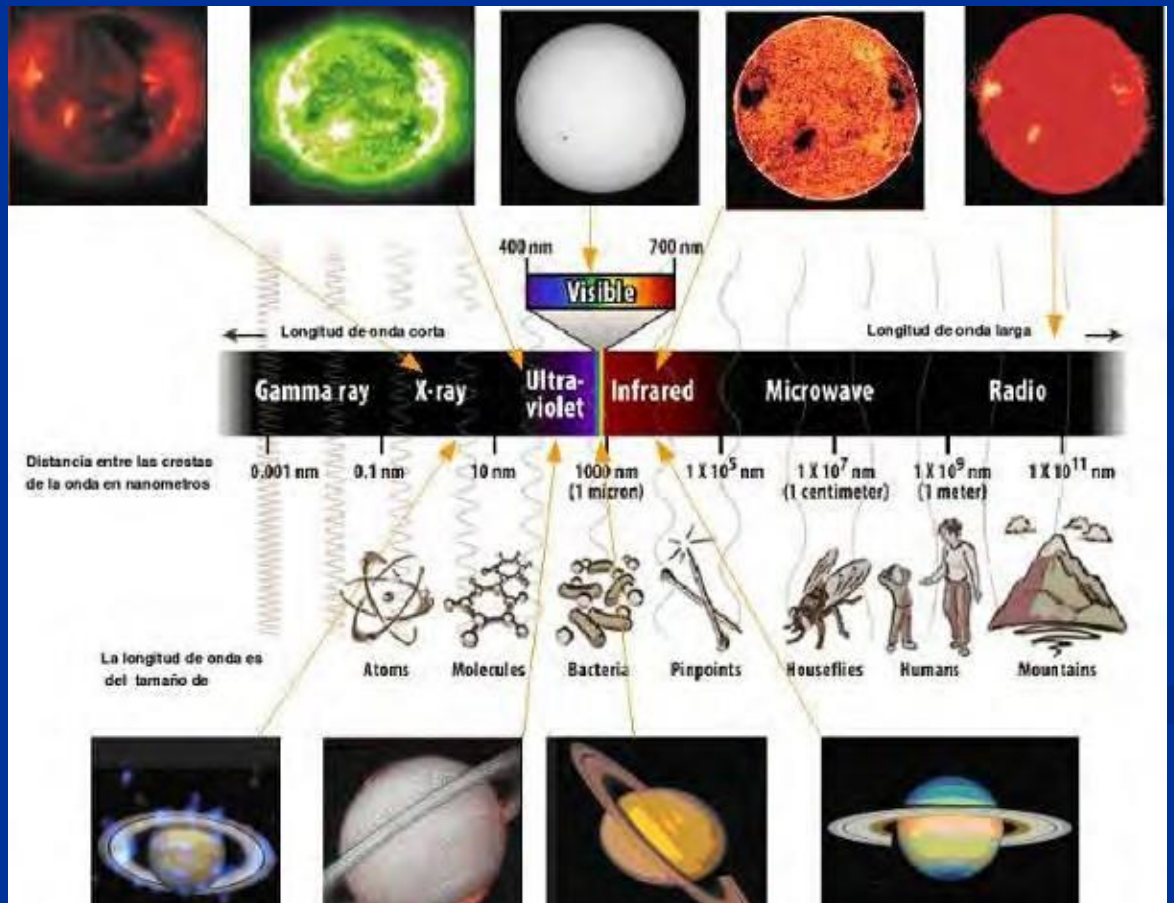
- **For centuries, the universe had been studied only with the light detected by the human eye.**
- **There is information that comes electromagnetic waves of other wavelengths that our eyes cannot see.**
- **Astronomers observe today in the radio, microwave, infrared, ultraviolet, X-rays and gamma rays as well as in visible rays.**
- Kwa karne nyingi, ulimwengu ulikuwa umechunguzwa tu kwa nuru iliyogunduliwa na jicho la mwanadamu.
- Kuna habari ambayo huja mawimbi ya sumakuumeme ya urefu mwingine wa mawimbi ambayo macho yetu hayawezi kuona.
- Wanaastronomia huchunguza leo katika redio, microwave, infrared, ultraviolet, X-rays na gamma rays na pia katika miale inayoonekana.

Electromagnetic Spectrum

Spectrum ya Umeme

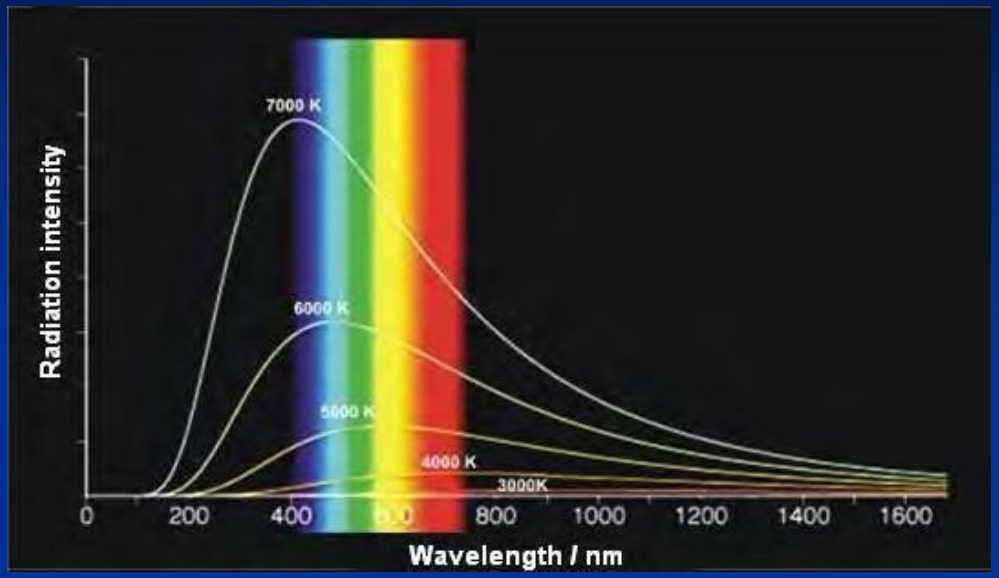
All wavelengths of electromagnetic radiation.

All wavelengths of electromagnetic radiation.



Blackbody Radiation

Mionzi ya Blackbody



Any "black body" when heated emits light at many wavelengths.

"Mwili mweusi" wowote unapokanzwa hutoa mwanga kwa urefu wa mawimbi mengi.

By studying the radiation of a distant object, we can measure its temperature without having to go there.

This applies for the stars, which are almost black

Bodies

Kwa kusoma mionzi ya kitu kilicho mbali, tunaweza kupima joto lake bila kwenda huko.

Hii inatumika kwa nyota, ambazo ni karibu nyeusi miili

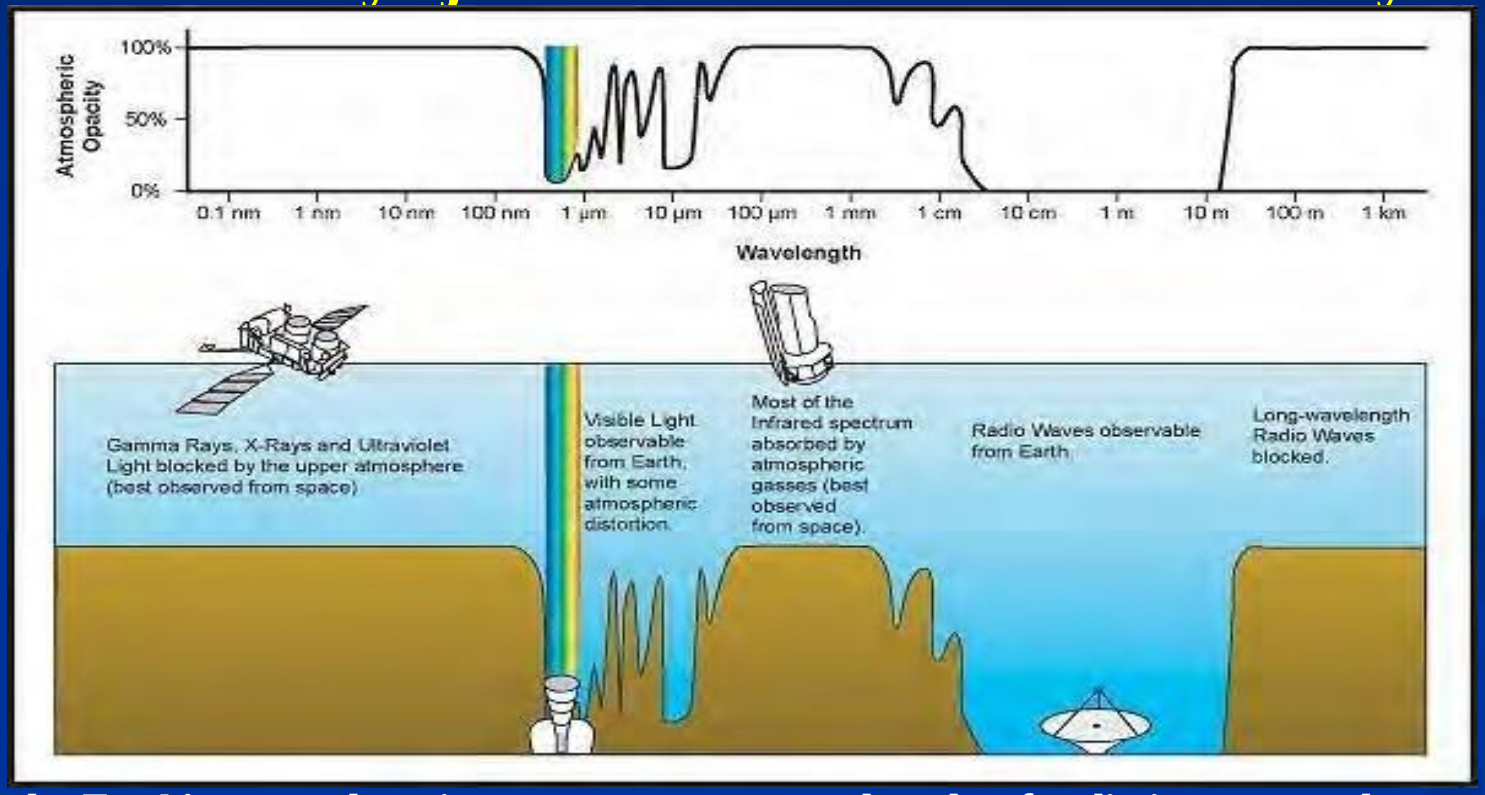
There is λ_{max} at which the intensity of radiation is maximum. This λ_{max} depends on the temperatura T:

$$\lambda_{max} = \frac{2.898 \times 10^{-3}}{T} \quad (m)$$

Wien's Law

Solar radiaton Windows for different energy regions

Radi ya jua Windows kwa maeneo tofauti ya nishati

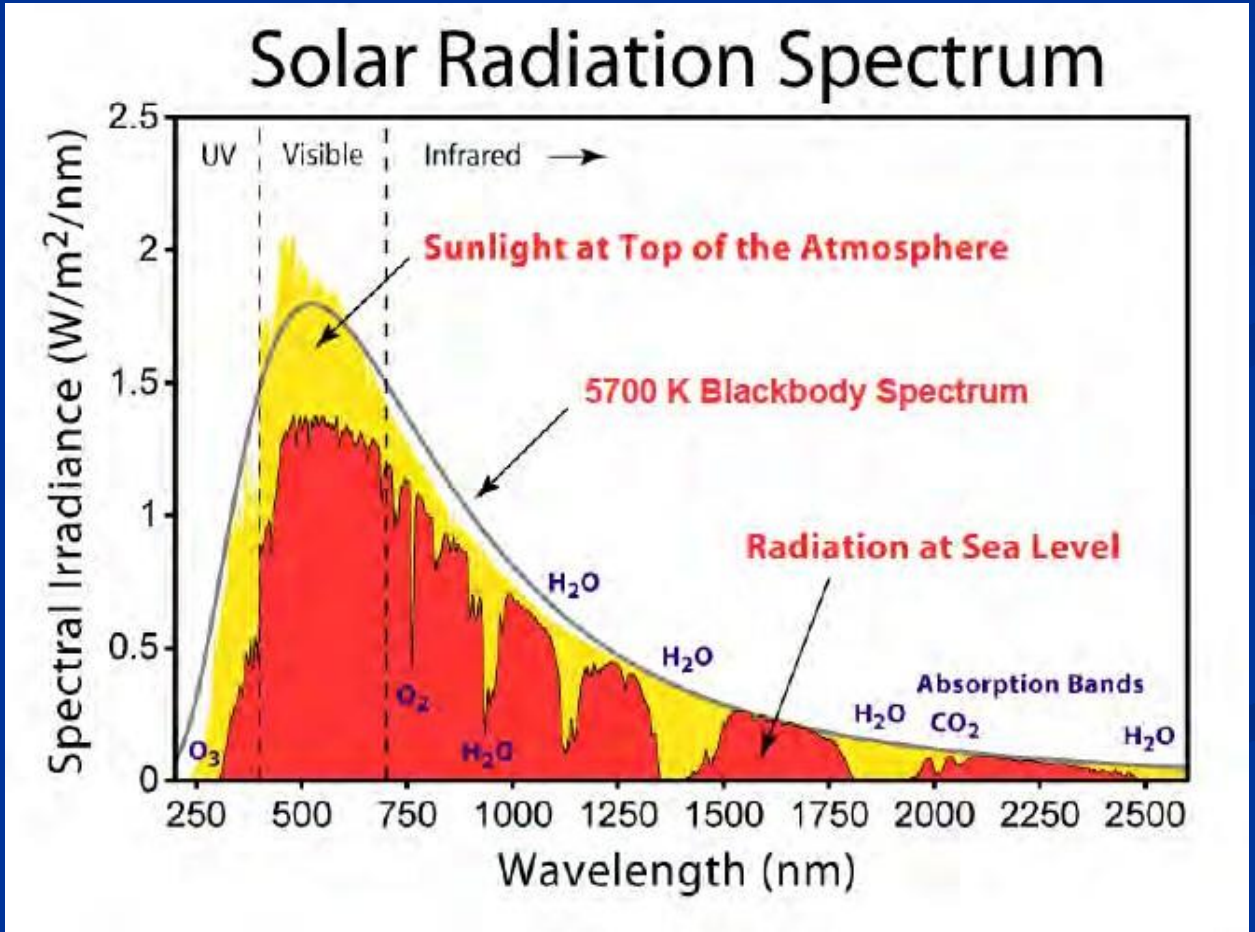


The Earth's atmosphere is opaque to most wavelengths of radiation. Wecan detect the hight energies from space and low energies require special detectors.

Angahewa ya dunia ni opaque kwa urefu wa mawimbi mengi ya mionzi. Tunaweza kutambua nishati ya juu kutoka kwa nafasi na nishati ya chini huhitaji vigunduzi maalum.

When the solar electomagnetic energy goes through the atmosphere, the "black body" radiation change, but the λ_{max} at which the irradiance is máximum remains almost without change

Wakati nishati ya sumakuumeme ya jua inapitia angahewa, mionzi ya "mwili mweusi" hubadilika, lakini λ_{max} Kiwango cha juu ambacho mwako ni wa juu zaidi hubakia karibu bila mabadiliko



Weknow that there is λ_{max} at which the irradiance or emision is maximum depends on the temperature T, but it does not need to be in a visible region of the spectrum

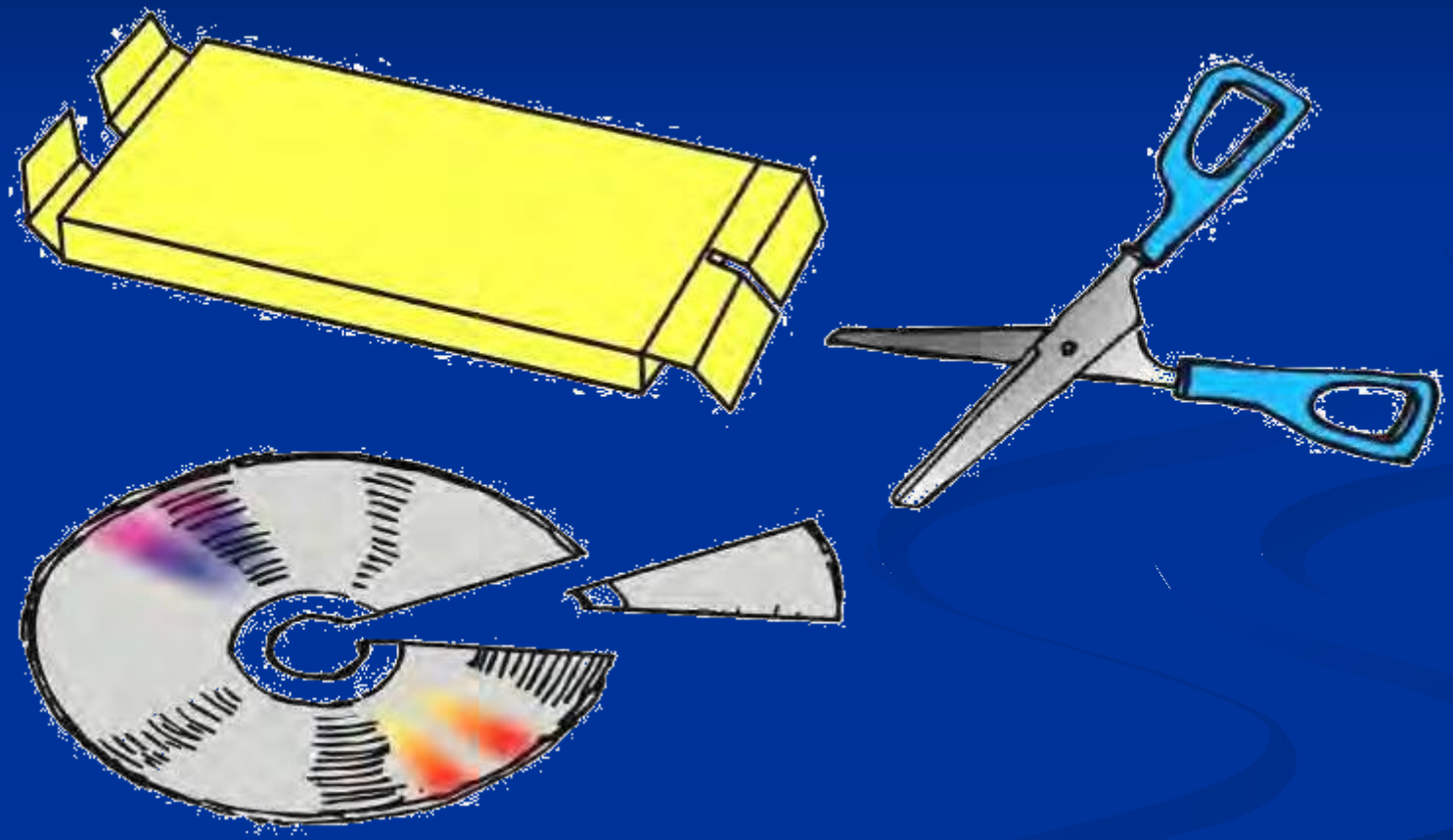
Tunajua kuwa kuna λ_{max} max ambayo mwara au utoaji ni wa juu zaidi inategemea joto T, lakini hauhitaji kuwa katika eneo linaloonekana la wigo.

For example, the human body has a temperature of T = 273+37 = 310 K. Then, emits the maximun in $\lambda_{máx}$ = 9300 nm.

The night vision devices uses this $\lambda_{máx}$.

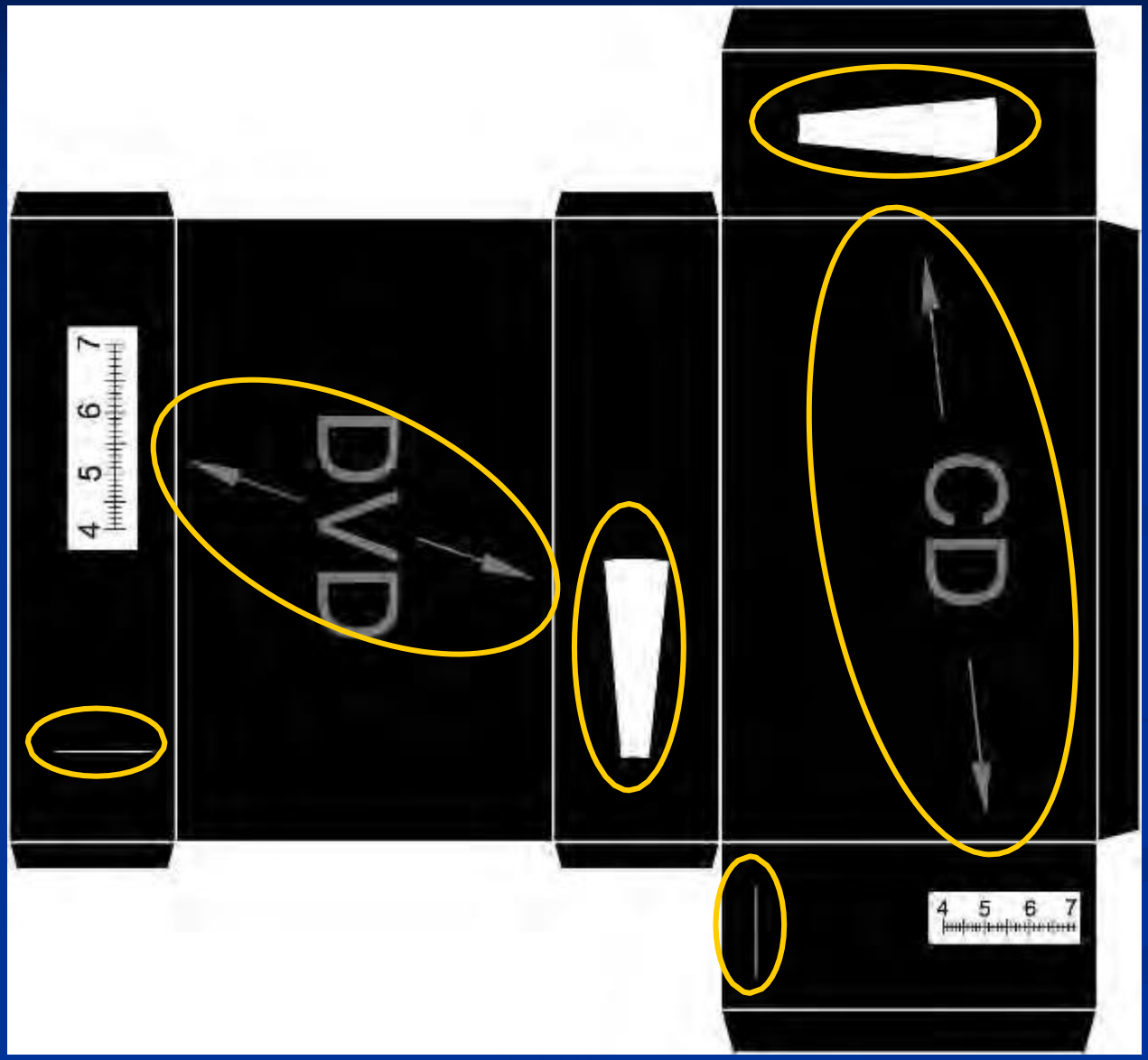
Activity 1: Building a spectrometer

Shughuli 1: Kujenga spectrometer



Activity 1: Building a spectrometer

Shughuli 1: Kujenga spectrometer



Depending what you use, a DVD part or a CD one, you cut the matching portions the template.

Kulingana na kile unachotumia, sehemu ya DVD au CD moja, unakata sehemu zinazolingana za kiolezo.

Activity 1: Building a spectrometer

Shughuli 1: Kujenga spectrometer

Remove the metal layer of the CD using tape or scratching it.

NB! The coating will not peel off white or commercial CDs.

Ondoa safu ya chuma ya CD kwa kutumia mkanda au kuikwangua.

NB! Mipako haitaondoa CD nyeupe au za kibiashara.

Activity 1: Building a spectrometer

Shughuli 1: Kujenga spectrometer

The black surface folded on the inside.

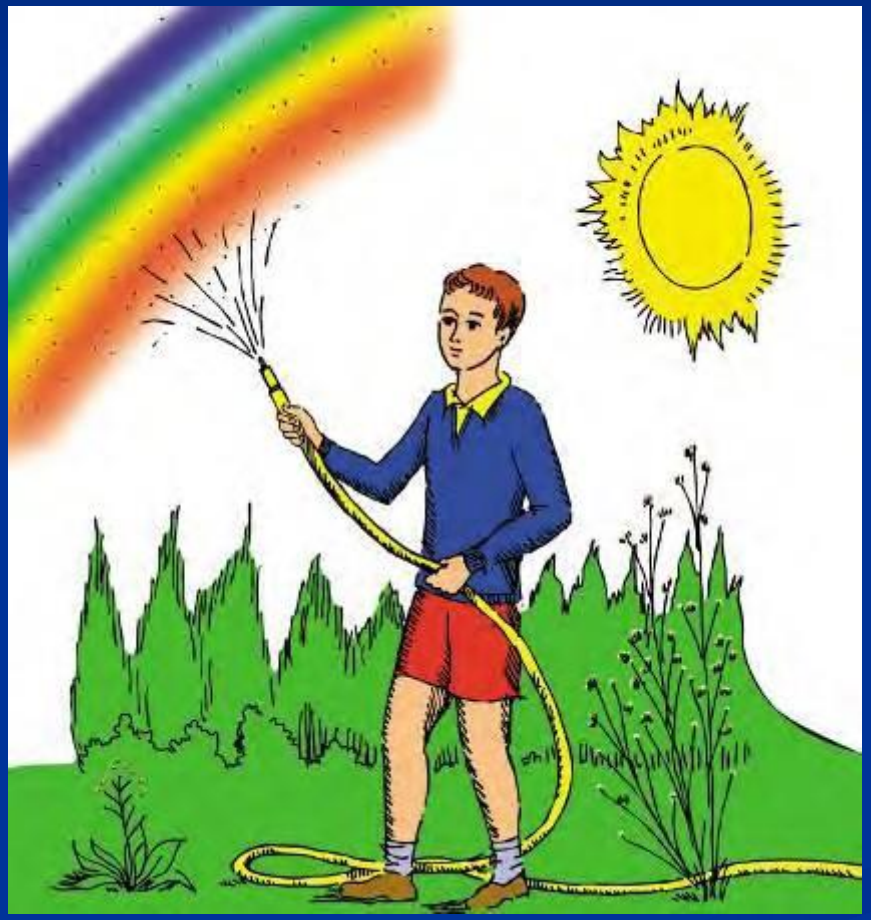
Uso mweusi ulijikunja kwa ndani.

Compare the spectra from filament lamps, fluorescent lamps and streetlights.

Linganisha spectra kutoka kwa taa za filament, taa za fluorescent na taa za barabarani

Activity 2: Decomposing sunlight with water drops

Shughuli 2: Kuoza kwa mwanga wa jua kwa matone ya maji



Children can split the sunlight and make a rainbow.

They need a hose with a fine spray. They must have their back to the Sun.

Watoto wanaweza kugawanya mwanga wa jua na kufanya upinde wa mvua.

Wanahitaji hose na dawa nzuri. Lazima wawe na mgongo wao kwa Jua.

Other regions of the spectrum

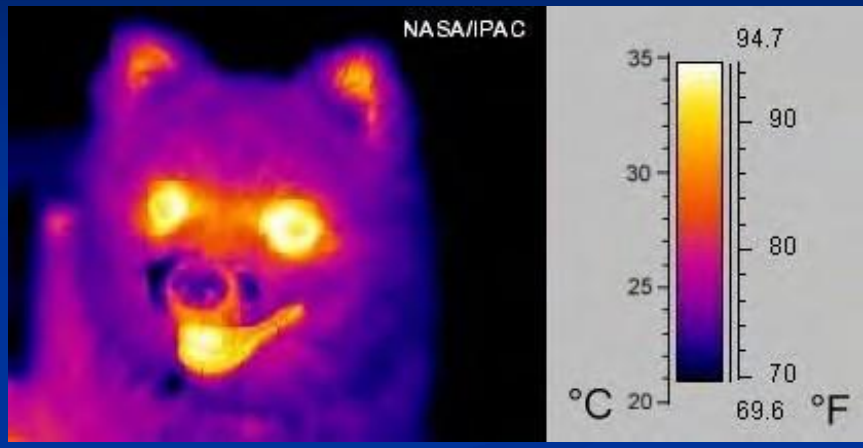
Mikoa mingine ya wigo

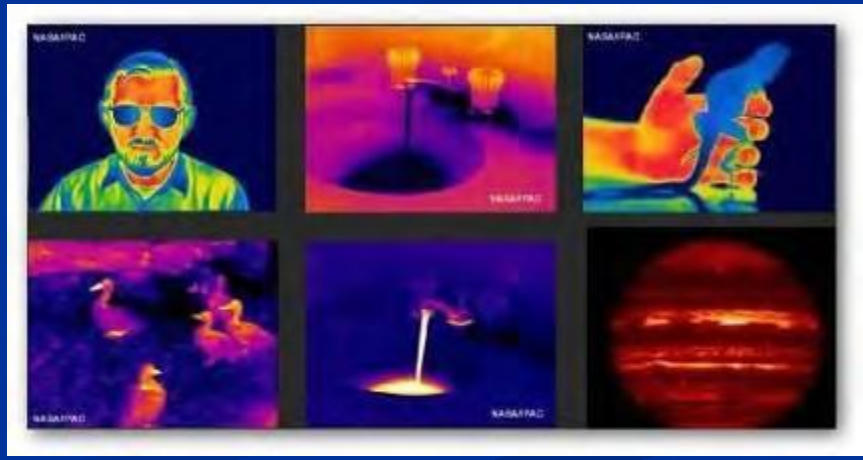
- There is a matter with a temperature much lower than that of the stars, for example, clouds of interstellar matter.
- They do not emit visible radiation, but emit infrared radiation, microwaves and radio waves.
- The type of radiation is associated with the processes that are occurring inside the object. E.g., details in the centre of our galaxy …
- Kuna jambo lenye halijoto ya chini sana kuliko ile ya nyota, kwa mfano, mawingu ya maada kati ya nyota.
- Hazitoi mionzi inayoonekana, lakini hutoa mionzi ya infrared, microwaves na mawimbi ya redio.
- Aina ya mionzi inahusishwa na taratibu zinazotokea ndani ya kitu. K.m., maelezo katikati ya galaksi yetu ...

The infrared radiaton

Radi ya infrared

- **William Herschel discovered the infrared using the prism and thermometers.**
- **It is a property of warm bodies, even those not hot enough to emit visible light.**
- **To highlight this radiation we establish an equivalence between temperature and colour.**





- William Herschel aligundua infrared kwa kutumia prism na vipima joto.
- Ni mali ya miili yenye joto, hata ile isiyo na moto wa kutosha kutoa mwanga unaoonekana.
- Ili kuangazia mionzi hii tunaweka usawa kati ya halijoto na rangi.

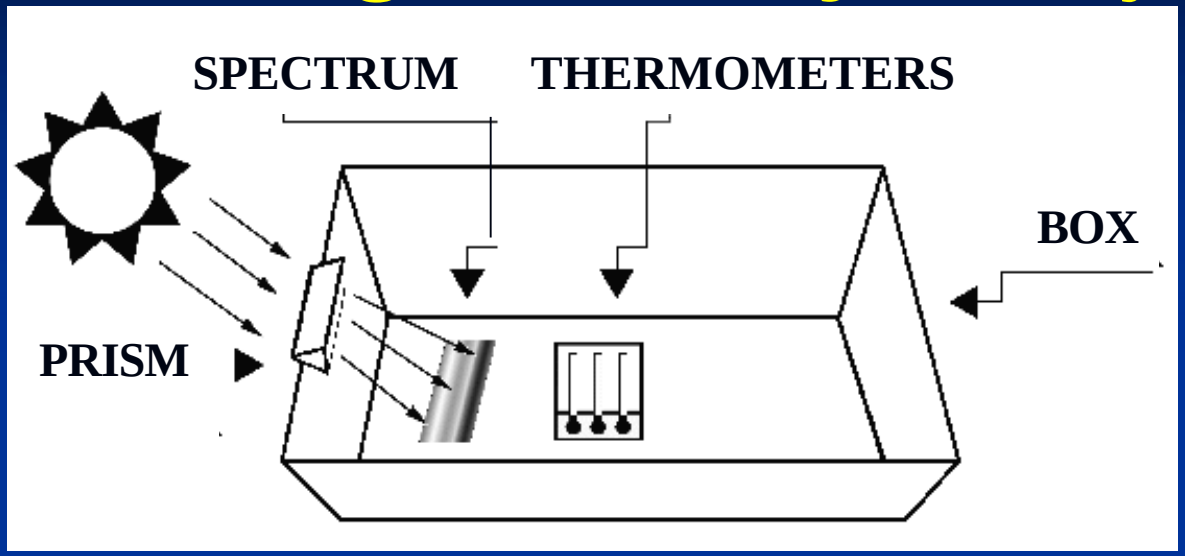
Activity 3: Herschel Experiment

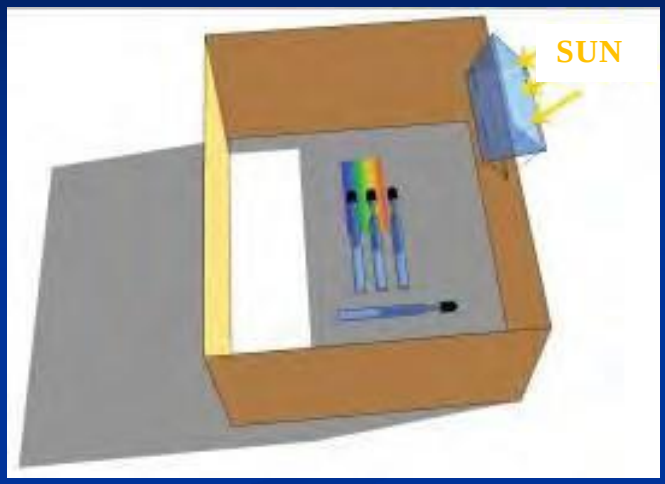
Shughuli 3: Majaribio ya Herschel

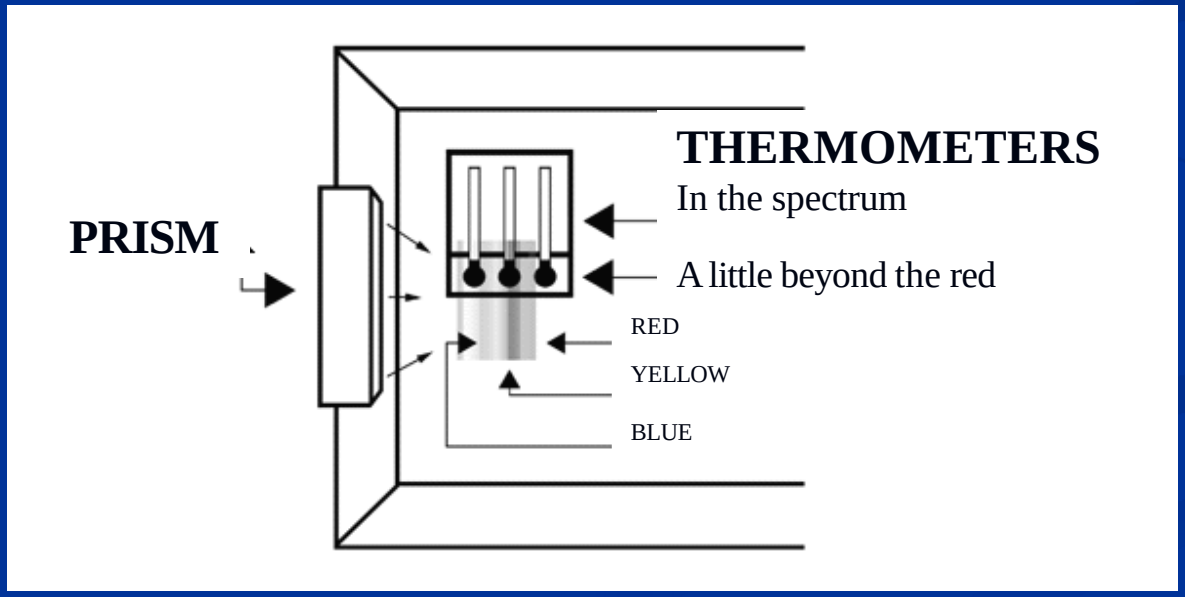
- **In 1800, Herschel discovered the infrared in sunlight.**
- Mnamo 1800, Herschel aligundua infrared kwenye mwanga wa jua.

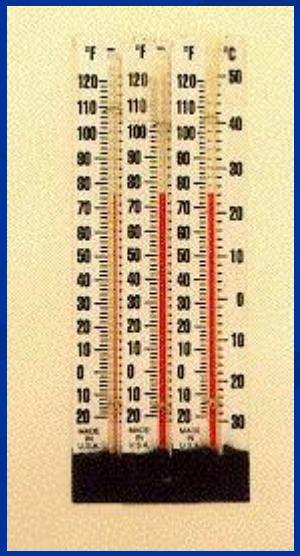
Activity 3: Herschel Experiment

Shughuli 3: Majaribio ya Herschel



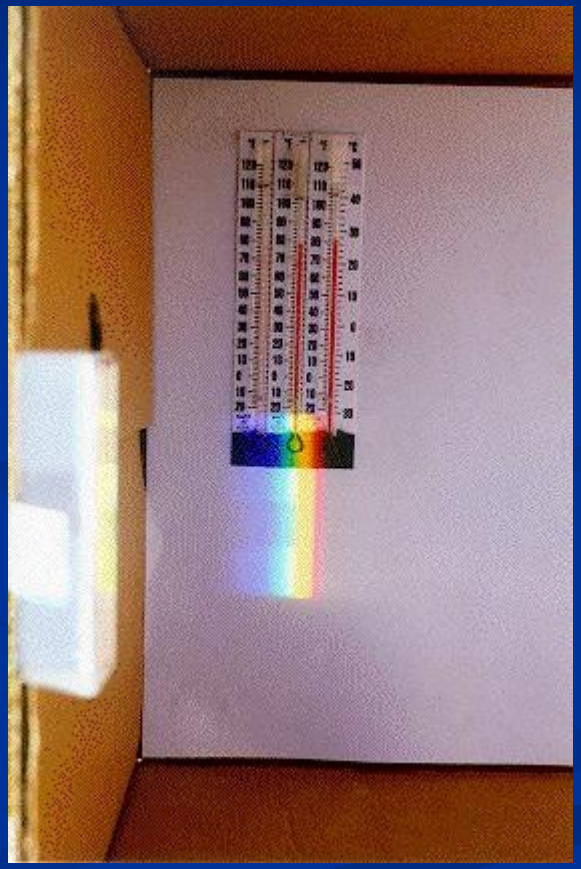






Activity 3: Herschel Experiment

Shughuli 3: Majaribio ya Herschel



Activity 3: Herschel Experiment

Shughuli 3: Majaribio ya Herschel

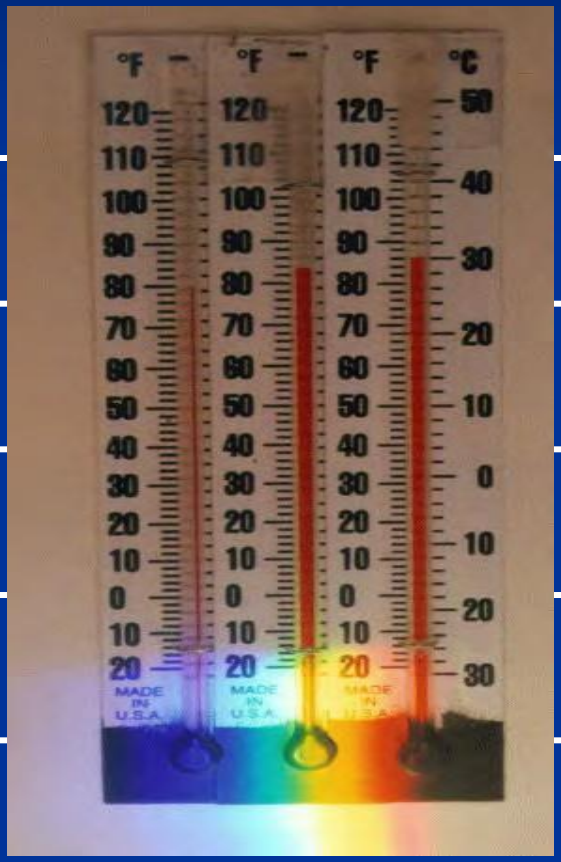


TABLE OF DATA COLLECTION

	Thermometer No. 1 in the blue	Thermometer No. 2 in the yellow	Thermometer No. 3 beyond the red	Thermometer No. 4 in the shadow
After 1 minute				
After 2 minutes				
After 3 minutes				
After 4 minutes				
After 5 minutes				

Activity 4: IR detection with a pone

Shughuli 4: Utambuzi wa IR kwa simu

- **Remote controls emit infrared signals but our eyes cannot see them.**
- **Many but not all mobile phones cameras are sensitive in IR.**
- Vidhibiti vya mbali hutoa ishara za infrared lakini macho yetu hayawezi kuziona.
- Kamera nyingi lakini si zote za simu za mkononi ni nyeti katika IR.

The power of the infrared

Nguvu ya infrared

- **The interstellar dust absorbs visible light but not infrared so much.**
- Vumbi la katikati ya nyota huchukua mwanga unaoonekana lakini

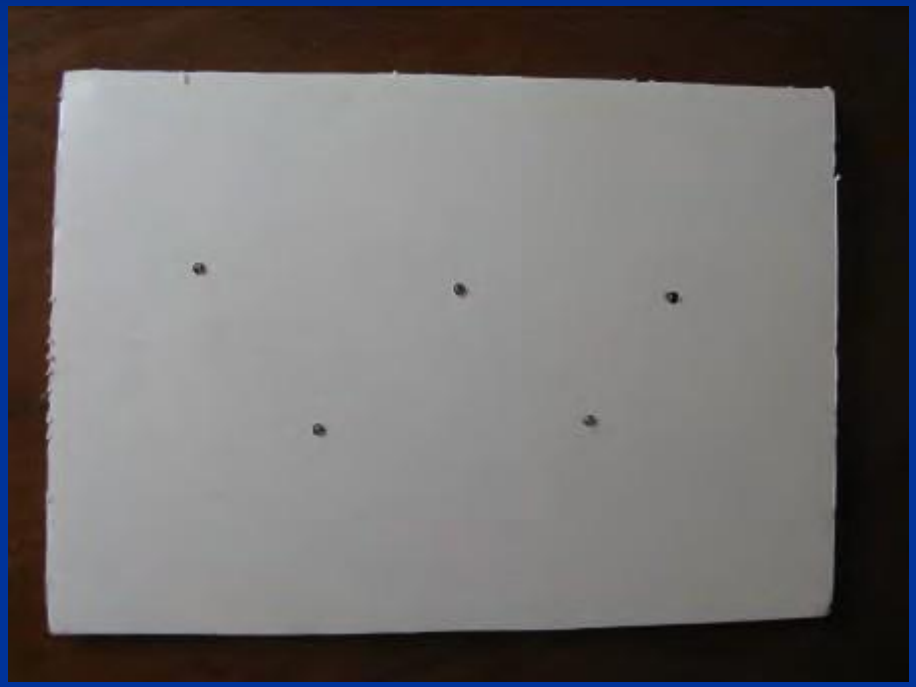
Activity 5: Detection of IR light of a bulb

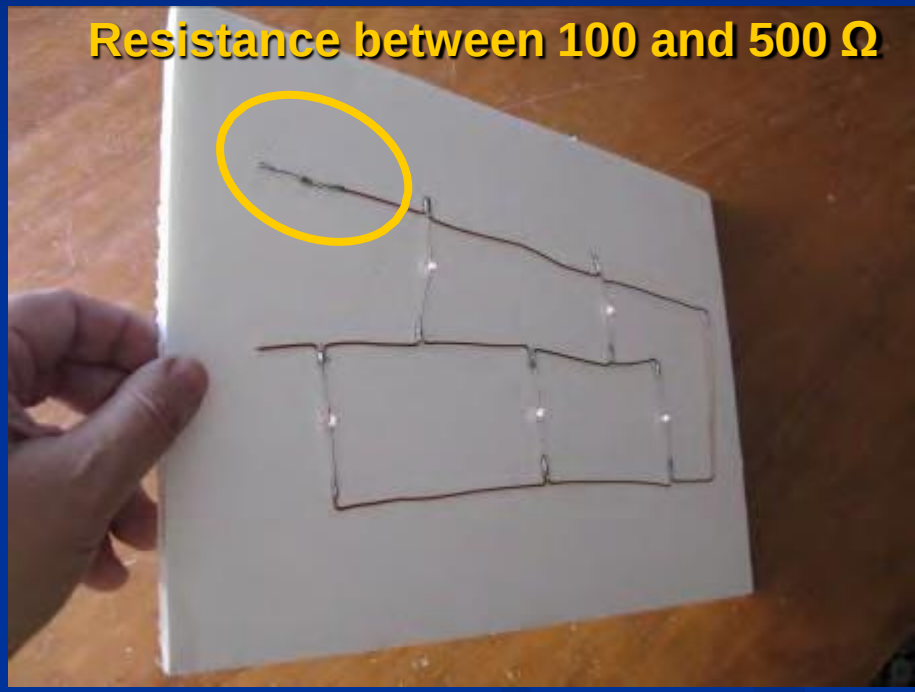
Shughuli 5: Kugundua mwanga wa IR wa balbu

- **Most of the energy emitted by an incandescent bulb is in the visible region, but it also emits infrared that can penetrate some fabrics that cannot be penetrated with visible radiation.**
- **The same happens with the galactic dust, which can be detected from its infrared emissions, but is opaque in the visible region.**
- Nishati nyingi zinazotolewa na balbu ya incandescent ziko katika eneo linaloonekana, lakini pia hutoa infrared ambayo inaweza kupenya baadhi ya vitambaa ambavyo haviwezi kupenya na mionzi inayoonekana.
- Vile vile hufanyika na vumbi la galactic, ambalo linaweza kugunduliwa kutoka kwa uzalishaji wake wa infrared, lakini ni opaque katika eneo linaloonekana.

Activity 6: Constellation with IR LEDs

Shughuli ya 6: Nyota yenye taa za IR





Cassiopeia with IR LEDs.

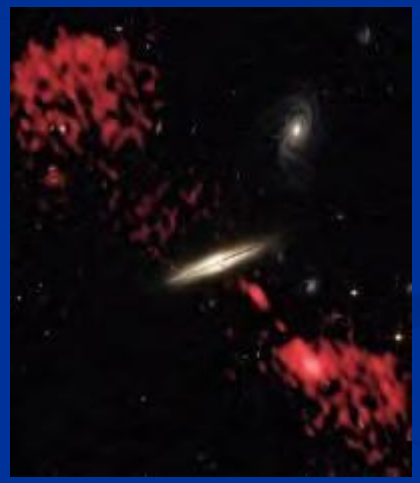
Activity 7: Constellation with remote controls

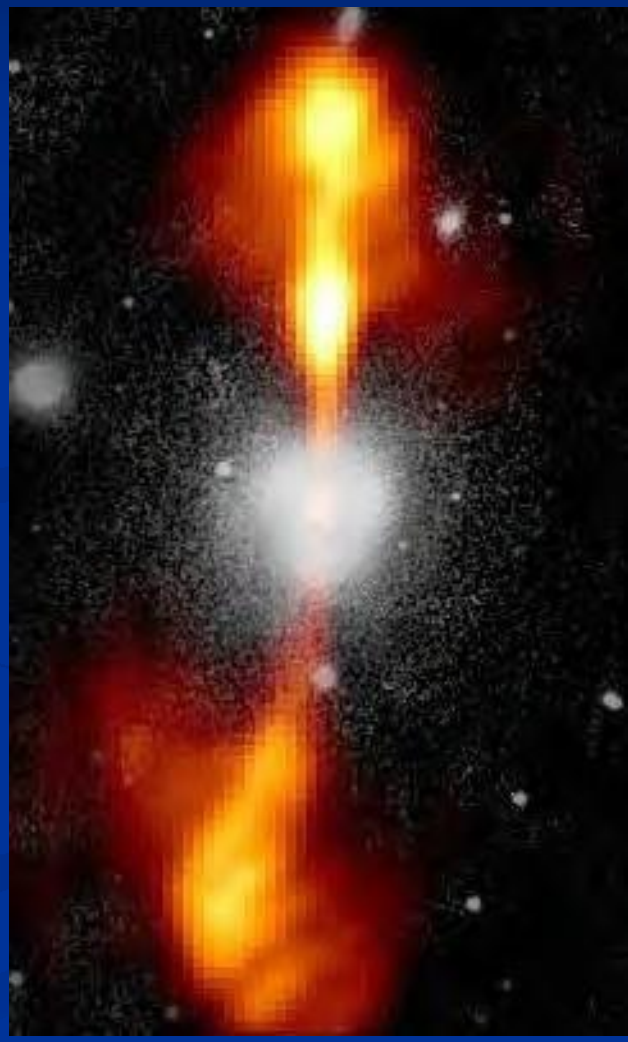
Shughuli ya 7: Nyota yenye vidhibiti vya mbali

Emission of radio waves

Utoaji wa mawimbi ya redio

- **EM radiation with wavelengths from metres to kilometres is called radio waves.**
- **They are used for commercial stations.**
- **Radio waves also come from space, and thus provide information that cannot be seen at other wavelengths.**

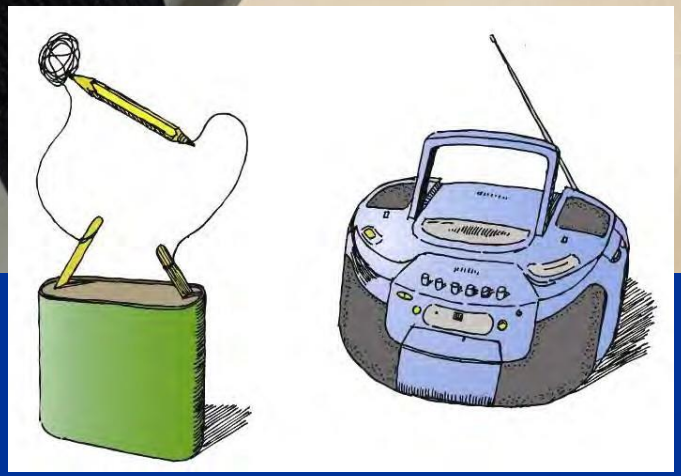




- Mionzi ya EM yenye urefu wa mawimbi kutoka mita hadi kilomita inaitwa mawimbi ya redio.
- Zinatumika kwa vituo vya biashara.
- Mawimbi ya redio pia hutoka angani, na hivyo kutoa habari ambayo haiwezi kuonekana katika urefu mwingine wa mawimbi.

Activity 8: Producing radio waves

Shughuli 8: Kuzalisha mawimbi ya redio



Ultraviolet radiation

Mionzi ya ultraviolet

- **UV photons have higher energies than those of visible light.**
- **UV destroys the chemical bonds between organic molecules.**
- **At high doses UV can be fatal for life.**
- **UV-C radiation is filtered by atmospheric ozone.**

- Fotoni za UV zina nguvu nyingi zaidi kuliko zile za mwanga unaoonekana.
- UV huharibu vifungo vya kemikali kati ya molekuli za kikaboni.
- Katika viwango vya juu UV inaweza kuwa mbaya kwa maisha.
- Mionzi ya UV-C huchujwa na ozoni ya angahewa.

Johann Ritter discovered ultraviolet radiation in 1801

Ultraviolet radiation

Mionzi ya ultraviolet

- **The Sun emits UV radiation, but most of it is filtered by the ozone layer at the top of our atmosphere; the amount that arrives on Earth is beneficial for life.**
- **This radiation is what makes our skin to tan.**
- **If the ozone layer decreased in thickness, the Earth would receive higher doses and skin cancers would proliferate.**

- Jua hutoa mionzi ya UV, lakini mingi yake inachujwa na safu ya ozoni iliyo juu ya angahewa yetu; kiasi kinachofika duniani kina manufaa kwa maisha.
- Mionzi hii ndiyo inayofanya ngozi yetu kuwa nyororo.
- Ikiwa safu ya ozoni ingepungua kwa unene, Dunia ingepokea viwango vya juu na saratani ya ngozi ingeongezeka.

Ultraviolet light

Nuru ya ultraviolet

Andromeda Galaxy in visible light (Hubble)

Andromeda Galaxy in UV light (Swift)

Activity 9: Black light (UV)

Shughuli ya 9: Mwanga mweusi (UV)

- **Counterfeit detector for bank notes and identity cards.**
- Kigunduzi bandia cha noti za benki na kadi za utambulisho

Activity 10: Filter UV radiation

Shughuli 10: Chuja mionzi ya UV

- **Black light bulbs are detectors for fake money .**
- **Fluorescent material (reacts to UV light).**
- **Common glass and glasses (no organics glasses, because they are plastic): depending on the type of glass, some or all of the UV is absorbed, plastic does not.**
- Balbu nyeusi ni vigunduzi vya pesa bandia. /Nyenzo za fluorescent (humenyuka kwa mwanga wa UV)/Kioo cha kawaida na glasi (hakuna glasi za kikaboni, kwa sababu ni plastiki): kulingana na aina ya kioo, baadhi au UV yote huingizwa, plastiki haifanyi.

Fluorescent material and glasses, illuminated with white light.

Nyenzo za fluorescent na glasi, zilizoangaziwa na mwanga mweupe.

The same material and glasses but illuminated with UV light.

Nyenzo sawa na glasi lakini iliyoangaziwa na mwanga wa UV.

Shadow of the glasses on the material

Kivuli cha glasi kwenye nyenzo

Activity 10: Filter UV radiation

The ozone layer is created by the interaction between light and O_2 : $O_2 + hv \rightarrow O + O$ (hv: UV energy of photodissociation)

$$O_2 + O \rightarrow O_3$$

And at the same time O3 filters the UV:

$$O_3 + hv \rightarrow O_2 + O$$

This is the right balance for the development of life.

Huu ndio usawa sahihi kwa maendeleo ya maisha

Ni muhimu kutumia miwani maalum ya jua ili kuepuka uharibifu wa retina!

(na kichungi cha UV)

X-rays

- **More energetic than UV is the X-ray radiation.**
- **It is used for radiographs and other medical imaging techniques.**
- Nguvu zaidi kuliko UV ni mionzi ya X-ray.
- Inatumika kwa radiographs na mbinu zingine za uchunguzi wa matibabu.

X-rays

More energetic than UV

Nguvu zaidi kuliko UV

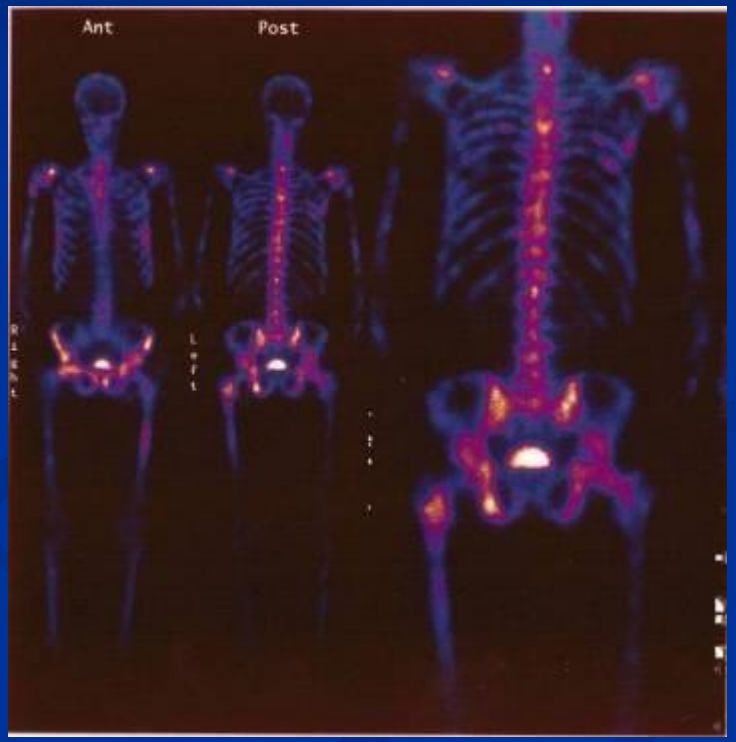
- **In the cosmos, X-ray radiation is acharacteristic of high- energy events and objects: black holes, star collisions, etc.**
- **The mission of the Chandra Space Telescope is to detect and monitor these kinds ofevents and objects**

- Katika ulimwengu, mionzi ya X-ray ni tabia ya matukio ya juu ya nishati na vitu: mashimo nyeusi, migongano ya nyota, nk.

- Dhamira ya Darubini ya Anga ya Chandra ni kugundua na kufuatilia aina hizi za matukio na vitu

Gamma rays
Mionzi ya Gamma

- **It is the most energetic radiation.**
- **On the Earth these rays are emitted by most of radioactive elements.**
- **Like X-rays, both are used in medicine, in imaging tests and in therapies to cure diseases like cancer.**
- Ni mionzi yenye nguvu zaidi.
- Kwenye Dunia miale hii hutolewa na vitu vingi vya mionzi.
- Kama X-rays, zote mbili hutumiwa katika dawa, katika vipimo vya picha na katika matibabu kuponya magonjwa kama saratani.



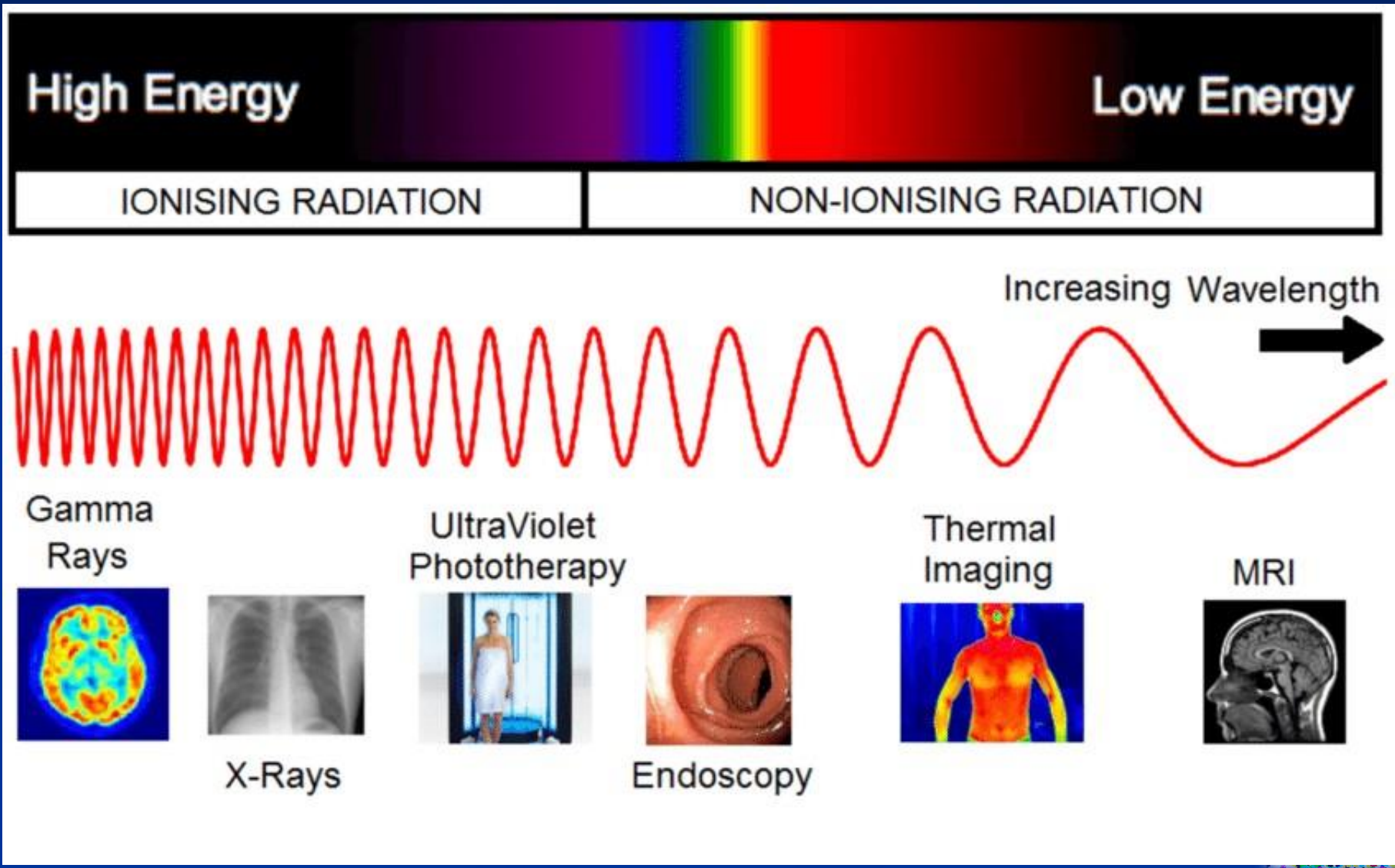
Gamma rays

Mionzi ya Gamma

- **The occasional violent eruptions of gamma rays are not unusual in the sky.**
- **There are different types that last from seconds to hours. One problem is to define their exact location to help identify what objects are producing the radiation.**
- **Astronomers tend to associate them with the fusion of binary stars, which can result in a black hole being formed.**
- Milipuko mikali ya mara kwa mara ya miale ya gamma si ya kawaida angani.
- Kuna aina tofauti ambazo hudumu kutoka sekunde hadi masaa. Tatizo moja ni kufafanua eneo lao halisi ili kusaidia kutambua ni vitu gani vinatoa mionzi.
- Wanaastronomia huwa na tabia ya kuzihusisha na muunganiko wa nyota binary, ambayo inaweza kusababisha shimo jeusi kuundwa.

Fermi's Five-year View of the Gamma-ray Sky

Uses of EM radiation in Medicine



Use of Radio Waves

- Magnetic resonance, diagnosis of soft tissues

MRI Human heart

MRI Normal knee

Use of X-rays

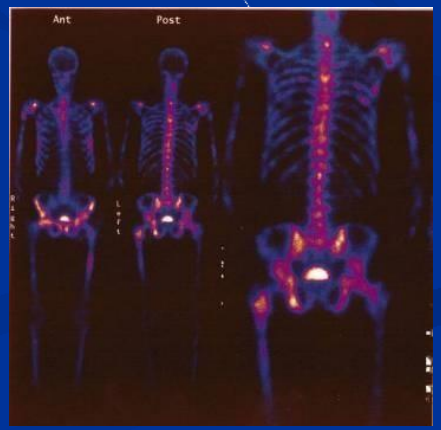
- Radiographs and computed axial tomography (CAT scan)

X-ray

CAT Normal knee

Use of Gamma-rays

- Imaging tests and therapies to cure diseases like cancer. Used in positron emission tomography (PET scan)



Thank you very much for your attention!

Asante sana kwa umakini wako!