

Making the Invisible Visible

Infrared into the Future

Infrared technology has been around for several decades in the form of remote control devices. One way to make it “visible” to students is by repeating Herschel’s classic experiment. Sir Frederick Herschel (1738-1822) used a prism to separate the colors of white light and demonstrated that within the invisible area next to red light was something that caused the temperature reading of a thermometer placed there to be higher than the temperature reading of thermometers placed in the visible regions of the spectrum. (coolcosmos.ipac.caltech.edu/cosmic_classroom/classroom_activities/herschel_experiment.html). Dr. Tim Kane of Penn State University, in conjunction with researchers at Duke, Stanford, and the Georgia Institute of Technology, is taking infrared technology to the next level.

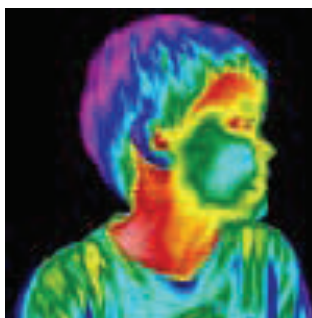
Using infrared radiation (IR) in the Mid- (2000-8000 nm) and Far-IR (8000-12000 nm), Kane

and colleagues hope to create new and far-reaching devices capable of useful in a broad range of applications including meteorology, homeland security, medicine, and free-space communications.

Advances in both materials and devices provide new opportunities for research and development of IR.

Using newly developed materials, the researchers hope to produce active multispectral IR imaging systems test beds. These test beds will be used to study the possibility of both remote and local sensing applications.

For the remote sensing application, the system will be used to monitor near and at the Earth’s surface. Active sensing will allow solid target discrimination without the traditional ambiguities present in today’s systems. On a local level, such a system could be used to provide spectroscopic imaging about “fingerprints” of tissues, for monitoring cancerous versus non-cancerous tissues (especially the types of



tissues found in breast cancer). Or it might yield more reliable methods of chemical monitoring for use by first responders to a disaster.

The researchers will also be investigating the use of both broadband and tunable line-narrowed infrared lasers. These lasers will be capable of exceeding current output parameters of IR lasers.

Fun Facts

Did you know that infrared....

- ✦ Is being used to stimulate the growth of human gingival fibroblast
- ✦ Is being used to detect planets around nearby stars
- ✦ Is being used by firefighters to detect hot spots so that fires can be put out quickly
- ✦ Is being used to reduce pain and accelerate healing
- ✦ Has a wavelength about the size of a pin head

Curricular Connections

Out of sight, but not out of mind, infrared radiation (IR) plays an important role in new technologies as well as new science. Current uses of IR include:

Military: Using IR lasers to disrupt the guidance systems of launched surface to air and air to air missiles and send them off track.

Law enforcement: Using thermal imaging to corroborate or disprove suspects’ claims during crime investigations. When we sit on a couch, or walk around in a room, we leave “impressions” detectable

by IR scanning equipment.

Firefighting: Using thermal imaging to locate unconscious victims in smoke filled rooms. Visible light is scattered by smoke or fog. IR, however, is not, and allows firefighters to “see” through smoke.

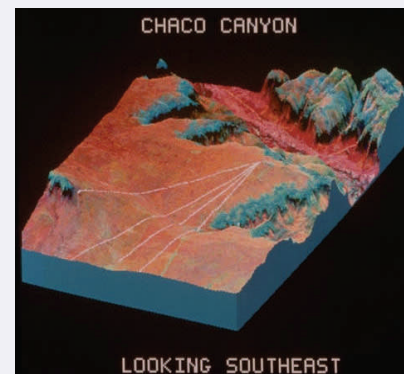
Archeology and anthropology: Detecting ancient civilizations and early human activity. Even slight depressions or compactions of the ground result in slightly different patterns of plants growing on it. IR sensors can detect these differences and reveal ancient human footprints or sites of ancient human cities.

Medicine: Determining hemoglobin concentration in pediatric patients, temperature measurement, heart surgery, investigating the effects of IR on the skin.

Biology: Studying special infrared detecting cells of pit vipers and beetles that search out prey using IR. Studying these materials may lead to new methods for IR detection as well as development of better materials for focusing and reflecting IR.

PA Standards

3.1.7.E	3.4.7C
3.4.10.C	3.4.12.C
3.8.7.B	3.8.10.B
3.8.12.B	



Research on Teaching & Learning

Common misconceptions concerning infrared include:

Understanding what is invisible. Most textbooks only briefly discuss infrared radiation, and its invisibility can make it difficult to understand. Replicating Herschel's historic experiment can help students "see" IR.

Heat energy is a totally separate phenomenon from infrared radiation. This misconception occurs largely because many textbooks and course curricula introduce heat and infrared radiation separately and do not draw clear connections between the two, resulting in confusion as to the relationship between them.

Only hot or glowing objects emit IR. Actually, all objects emit IR. IR is created by the

movement of atoms and molecules making up matter.

The faster this motion, the higher frequency the IR produced. In fact, by heating an object until it glows, much of the radiated energy is in the visible portion of the spectrum, and only a small part is in the IR. The amount of IR emitted depends on its temperature and the properties of the material. For example, a piece of plastic will emit more IR than will a piece of steel at the same temperature.

All IR is the same. Actually, IR spans a wide range of the electromagnetic spectrum, from about 760 nm to about 1,000,000 nm. Scientists divide the IR region of the EM spectrum into three parts—Near IR (NIR), Middle wavelength IR (MWIR) and Far IR (FIR), each of which has dif-

ferent properties and can be utilized in different ways.

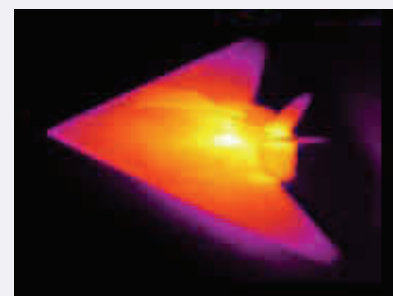
Materials that are useful for focusing and reflecting visible light are ineffective for IR. Glass, for example, which absorbs and emits visible light efficiently is a poor absorber and emitter of IR. Materials that are good for manipulating IR appear black to us, and are often composed of toxic elements, such as mercury, cadmium and telluride. Common table salt (NaCl) is great for absorbing and emitting MWIR, but due to its hydrophilic nature, is difficult to keep smooth (e.g., in lenses and mirrors). Scientists are studying special cells in pit vipers and beetles that locate prey using IR in hopes of learning about better materials for focusing and reflecting IR in IR based systems.



"Now the world has gone to bed,
Darkness won't engulf my head,
I can see by infrared,
How I hate the night."

Marvin's Lullabies

From *Life, the Universe,
and Everything.*
Douglas Adams



Opportunities @psu

Would you like to learn more about cutting-edge research in science? Penn State University offers a myriad of workshops and opportunities for teachers to learn about the most current topics. Through the PA Space Grant Consortium's *Science Workshops for Educators* series, Earth and Space Science teachers can, for example, learn how to estimate the number of galaxies in the universe using Hubble Space Telescope images. In another workshop on materials science, teachers will design and build "smart" sensors. All workshops in the series include the dissemination of easy-to-implement activities that are aligned with the PA Science

Standards. Visit <http://teachscience.psu.edu>.

Teachers today can use inexpensive probeware from companies like PASCO and Vernier to do experiments that Herschel couldn't imagine. Although summer workshop schedules haven't yet been announced, Penn State usually holds at least one such workshop each summer. We'll keep you posted

Research sabbatical fellowships sponsored by Boeing are available for teachers from the Philadelphia region to work at Penn State. Teachers in the program participate in research directed by PSU scientists and engineers.

Check the CSATS web-site (<http://csats.psu.edu>) for information about how to apply.

Information on obtaining mini-grants related to nuclear science in the amount of \$1,000-\$25,000 should be available soon at www.mne.psu.edu/minigrant.

K-12 teachers interested in participating in physics and materials research at PSU facilities while at the same time developing curriculum from their research experience can receive grants of up to \$3000 from the Penn State Center for Nanoscale Science (MRSEC): <http://www.mrsec.psu.edu/education/minigrant.asp>.

Links

<http://coolcosmos.ipac.caltech.edu/>

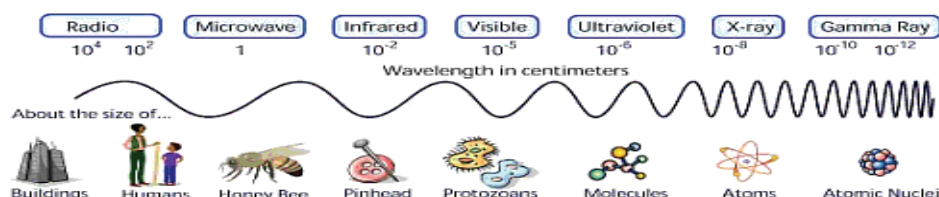
<http://imagers.gsfc.nasa.gov/ems/waves3.html>

<http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Optics.Guide.html>

<http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Space.Based.Astronomy.html>

Subject Matters is a publication of the Center for Science and the Schools (CSATS). This issue was written by Nathan Meyers, Mohammad Al Thowaini, and AnnMarie Ward, and edited by Bill Carlsen and Janell Howe.

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