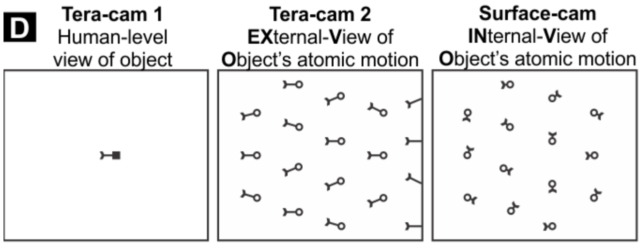
The Space-sci Sherlocks Discover



Atomic Views of Why Things Move, Internal Atomic Motion

Professor Du-Ane Du

www.Wacky1301SCI.com, *"Looking at serious science, sideways!"*

> Three sisters, Pico, Hectii, and Tera, the "Space-sci Sherlocks," are traveling through the Asteroid Belt. They stop to explore an asteroid and perform motion experiments involving internal atomic views of motion!
> —Excerpted from *Murdered Energy Mysteries*, Part 1, Chapter 3, by Du-Ane Du, (Amazon, Kindle, ebook 2018, paperback 2021).

"What happens when a brief push is given to a group of cold atoms?" Chip said.

"Is that the next question on the *Secrets of Murdered Energia… Greatest Conundrum* treasure hunt?" Pico asked.

"Sounds like the Space-sci Sherlocks need to do another asteroid experiment."

"Cold atoms?" Tera inquired, as she glided into their long narrow bedroom. "How cold do the atoms need to be?"

"Unknown," Chip said.

"Would shadow-cold be cold enough?" Pico said.

"Here in the Asteroid Belt, nothing is colder than shadow-cold," Tera said with a laugh, as she wrapped her hair into a bun.

Tera usually kept her hair in a bun when traveling through space—because without gravity, long hair tended to fly out in all directions. Pico, on the other hand, tended to keep her straight black hair in rows of small braids, interlaced with colorful beads.

"Hectii are you coming on this space walk?" Pico shouted.

"Maybe later," Hectii said. "My stomach is bothering me, so I'm going to rest a while."

Pico pushed off a wall and glided past the spacesuit closet, saying, "I'll ask Daddy to park our spaceship on the dark side of our next asteroid. We should find many cold rocks and cold atoms on the shadowy side of an asteroid."

"Feel better soon, Hectii," Tera wished aloud, as she opened the spacesuit closet. "Join us when you feel better."

Before long, Tera and Pico anxiously exited the pressure door and glided toward a large, dark asteroid.

"Chip, what kind of rock is this?" Pico quizzed as she activated her helmet camera and took a picture of the rock in her gloved hand.

She and Tera were gliding along the surface of an asteroid that was many times larger than their family's spaceship. Their spaceship was hanging around the corner of the asteroid, out of sight.

There was no evidence of sunlight on this side of the asteroid. Light strips around their wrists and ankles glowed yellow and green, but beyond the beam of their helmet-lights everything appeared black and lifeless—perhaps spooky.

Chip performed a spectroscopic analysis of the picture that Pico had just taken. "The rock you're holding is made of nickel," Chip said. "It appears monatomic—that is to say pure nickel."

"How heavy is it?"

"Comparing the rock to the size of your glove, I estimate the nickel rock has a mass of 0.5 kg," Chip said.

“That rock should work,” Tera remarked, as she attached a small camera and light to the side of Pico’s rock. “Chip, set this camera to atomic zoom. That way we can see what’s happening to the atoms inside this rock.”

“I wonder,” Pico speculated. “If we view the atoms from the outside, will we see things differently?”

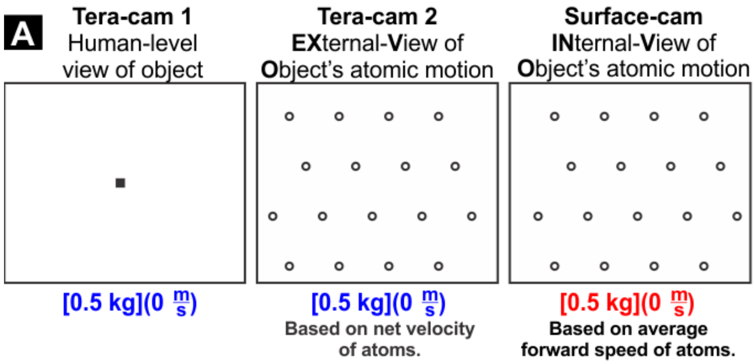
“What do you mean?” Tera said, as she handed the nickel rock back to Pico.

“Go stand by that outcropping,” Pico said pointing her helmet light at a nearby cliff face. “Attach two cameras and a traveling spotlight to that outcropping. Set one camera on a normal view of what I’m doing, and have the other camera zoom in on the atoms inside this nickel rock.”

“I see what you’re planning,” Tera said deductively, as she glided to the cliff face. “You want a human-level picture, an outside view of the atoms, and an inside view of the atoms.”

“Exactly,” Pico said, as she suspended the nickel rock in front of her. “Chip, can you coordinate the pictures?”

“Done,” Chip said. “I’m placing the pictures on your visor displays. I’ve added velocity and mass data to establish a baseline for future experiments.”



"Simple enough," Pico said after studying the pictures. "Nothing is moving. The nickel rock has a mass of 0.5 kg, and it has a momentum of 0 kgm/s."

"Both atomic-zoom cameras are showing the same thing," Tera established.

"Yes," Pico said, "but the captions are a little different."

"On the right, the INternal View of the Object's Atoms shows that the atoms have an average forward speed of zero."

"That means they also have a speed-momentum of zero," Pico said. "And in the middle picture, the EXternal View of the Object's Atoms shows that the atoms have a net velocity of zero."

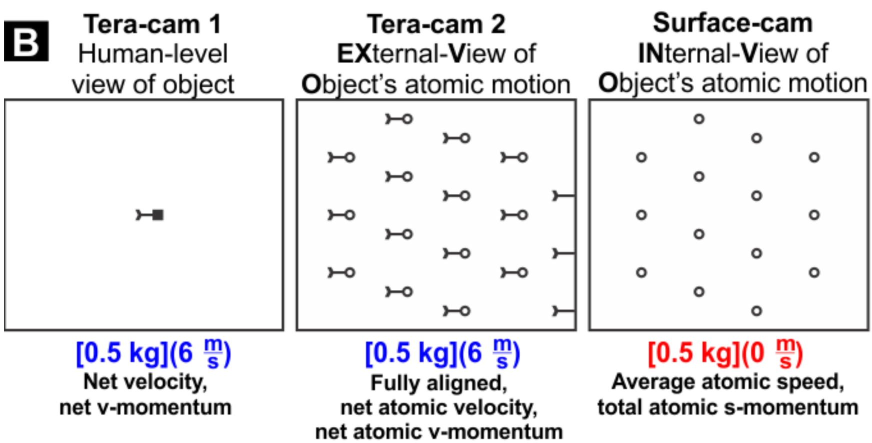
"Which means the velocity-momentum is also zero," Tera said conclusively. "Both views seem to be telling us the same thing."

"Maybe this'll make more sense if I give the rock a shove," Pico said. She pulled a retractable string from her belt and carefully tied the string to the nickel rock. She pressed the auto-stabilize button on her spacesuit.

“Take pictures of this rock as it glides past, Chip,” Pico directed, as she threw the rock to the right. She immediately began gliding backward. A brief puff of gas from the back of her space suit brought her to a stop.

Pico used the string to slow the rock and pull it back in.

“Here are the three pictures of the rock, as it glided to the right,” Chip said, as he placed the following on their visor displays:



“That’s unexpected,” Tera said after examining the picture. “Now the two atomic views are different. Using three cameras was a great idea, Pico!”

“Thank you,” Pico said gratefully. “And now I can see why Chip chose to title the pictures this way. Tera-cam 1 is taking a picture of the rock as we see it. We're the human level, and the motion we see is human-level motion."

"In the center picture, the **exvo-atomic motion** shows how the atoms move from our human point of view," Tera said. "We have the EXternal View of the Object's atoms."

"In contrast, the **invo-atomic motion** shows us how the atoms move with respect to the inside of the object," Pico said. "In the far-right picture, the invo-atomic motion hasn't changed. Putting this together, when I gave a brief push to the object, the brief push only affected the exvo-atomic motion. Chip, can you please explain why the invo-atomic view shows that the atoms aren't moving?"

"Certainly," Chip said. "The **invo-atomic average speed** is related to the temperature of the rock. Atoms that aren't moving around are associated with a temperature of **absolute zero**, or **zero kelvin**."

"You can't become slower than stopped," Tera explained. "At a temperature of zero kelvins, atoms stop moving with respect to the sides of the object."

"But the EXternal View of the Object's atoms shows that the atoms are moving," Pico rebutted. "The exvo-atomic motion is perfectly parallel, or perfectly aligned. But the exvo-atomic motion isn't affecting the internal temperature. It looks like an internal temperature of zero kelvins is based exclusively on the invo-atomic average forward speed."

"This asteroid must not be rotating," Tera deduced. "The dark side of the asteroid is never exposed to the sun—and the sun is very far away. As a result, the nickel rock you chose has a temperature of zero kelvins."

"But when I pushed the rock…" Pico said. "Wait, a brief push is also called an impulse. Let's look at this in terms of Newtonian motion fact #1."

"At first the rock wasn't moving. Then it had a rightward velocity of 6.0 m/s," Tera said. "That means you must've exerted an impulse [momentum transfer] on the rock."

"Let's see," Pico said, as she activated her data-input gloves and began keying. As she keyed, the letters and numbers appeared on both visor displays at the same time. "To find the amount of human-level impulse I gave to the rock, we subtract, like this:"

$$im\Delta\rho = mv_{final} - mv_{initial}$$

$$im\Delta\rho = (0.5\ kg)(6\frac{m}{s}) - (0.5\ kg)(0\frac{m}{s})$$

$$\boldsymbol{im\Delta\rho = 3.0\ kg\frac{m}{s}}$$ ***, or 3.0 ρ or 3.0 momentums***

appeared on their visor displays.

"If I may auto-adjust," Chip said. "To simplify notation, the Educational Reform Act of 2081 introduced the units, $\boldsymbol{\rho}$ or *rho* of momentum and $\boldsymbol{\rho}$ of impulse/momentum-transfer. Because the symbol $\boldsymbol{\rho}$ means momentum, it is sometimes read as *momentums* of impulse."

"Momentums of momentum does sound clever," Pico said appreciatively. "And thanks for auto-adjusting my data. Now the equation is telling us, I exerted an impulse of 3.0 ρ when I threw the rock—causing a momentum of 3.0 kgm/s, or 3.0 *momentums* of impulse."

"Look at this," Tera said. "The pictures are showing us the human-level momentum of the rock and the net exvo-atomic v-momentum are the same."

"Will that always be true?" Pico said.

"The center picture shows the nickel atoms have a net velocity of 6.0 m/s to the right," Tera said. "Right is the X-direction."

"That seems simple enough," Pico said. "All of the atoms are moving to the right at the same speed. There's no upward motion—upward would be in the Y-direction. And there's no sideways motion—sideways would be in the Z-direction."

"Very good," Tera commended. "Didn't Grandpa Proge say that we can use the Pythagorean Theorem to calculate the net velocity?"

"Yes," Pico said. "And we learned all about X, Y, and Z in my algebra class last year. Let's see, if X is 6, and Y is 0, and Z is 0, then the Pythagorean Theorem will produce an answer of 6 in the X-direction."

"And in our middle picture, we can see that the net velocity of the atoms is 6.0 m/s," Tera said neatly.

"But, how much exvo-atomic impulse [momentum transfer] did I give to the atoms of the rock?" Pico wondered, as she began tapping the fingertip keys inside her data-input gloves. "I bet it's—"

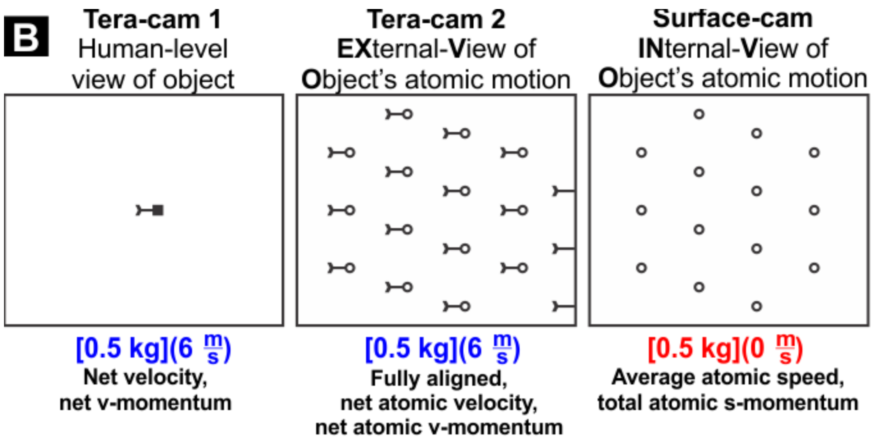
exvo-atomic im$\Delta\rho = mv_{final} - mv_{initial}$

exvo-atomic im$\Delta\rho = (0.5\ kg)(6\frac{m}{s}) - (0.5\ kg)(0\frac{m}{s})$

exvo-atomic im*$\Delta\rho$ *= 3.0 kg*$\frac{m}{s}$*, or 3.0* ρ *or 3.0 momentums

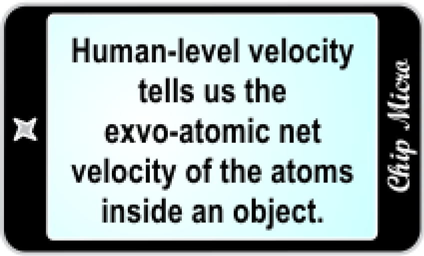
appeared on their visor displays.

"Your figures show that the exvo-atomic impulse is also 3.0 ρ," Tera said. "Therefore, the picture's caption is correct when it shows that the exvo-atomic impulse is the same as the human-level impulse."



"I guess they'll always be the same," Pico realized. "If you push the rock upward, the atoms inside the rock will have a net upward velocity that matches the upward velocity of the rock."

"That's true. After all, if one atom travels faster than the object, it would leave the object and become a gas atom," Tera said supportively. "If you think about it, the **exvo-atomic net velocity** must always be the same as the human-level net velocity of the entire object."



"Chip, does that answer today's *Secrets of Murdered Energia* question?" Pico said.

"Not completely," Chip said.

"Then what shall we test next?" Tera said.

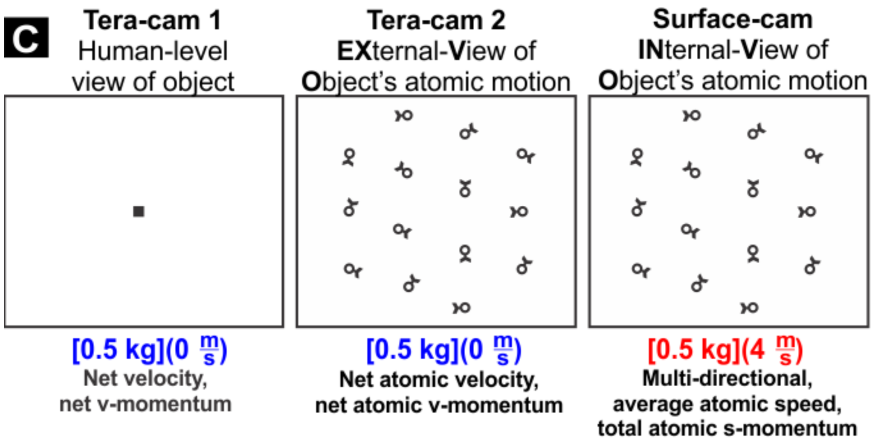
"I think I'll give my nickel rock a bunch of tiny pushes," Pico said. She grabbed a second rock that was floating nearby.

Pico held the original nickel rock in one glove, and she rhythmically struck the second rock against the nickel rock—several times on the top, on the bottom, left, right, front, and back. Each time, she heard a soft tap that sounded as if it was coming from far away.

"If we had an atmosphere, I'd hear the rocks clacking against one another," Tera submitted.

"I heard it a little through my spacesuit," Pico said, as she tossed the second rock back toward the surface of the asteroid. She reached out and suspended the nickel rock in front of her. "Focus your camera on the nickel rock, so Chip can take some more pictures."

"Here they are," Chip said, as three new pictures appeared on their visor displays:



“Fascinating,” Tera said compellingly. “There’s a lot of information here. Notice that the human-level view shows a net velocity of 0 m/s, and the EXternal View of the Object’s atoms also shows an exvo-atomic net velocity of 0 m/s.”

“That’s because I suspended the rock in space, rather than pushing it,” Pico said. “The atoms inside the rock have a combined/net X-velocity of zero, a net Y-velocity of zero, and a net Z-velocity of zero. That means the exvo-atomic net velocity is 0 m/s. Human-level net velocity is an excellent predictor of an object’s exvo-atomic net velocity.” (For more info on how vector addition works, see *Murdered Energy Mysteries*, Chapter 102.)

“Wait,” Tera said. “How do you know the net X-velocity is zero?”

“Because the rock isn’t moving in the X-direction, silly,” Pico said. “Oh I see, you asked that question to see if I understand what the word *net* means.

“Here’s how it works. If the atoms had an exvo-atomic net velocity of 1.0 m/s in the X-direction, then the entire rock would be moving forward,” Pico expanded. “The rock isn’t moving in any direction, so the exvo-atomic net velocity in the X-direction must be zero. In the same way, the net Y and net Z velocities also must be zero.”

“But look at the surface-cam picture, on the right,” Tera said. “It shows that the atoms now have an invo-atomic average forward speed of 4.0 m/s.”

“That means the nickel atoms are now bouncing around,” Pico said. “After all, invo-atomic means the INternal View of the Object’s Atoms.”

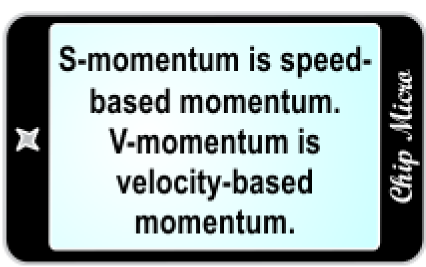
“And that must mean the rock now has a temperature slightly higher than 0 kelvins,” Tera ventured. “Remember, an object’s temperature is related to the average forward speed of the atoms.”

"And that's an invo-atomic measurement," Pico said precisely. "The rock itself isn't moving, but the atoms are moving with respect to the sides of the rock."

"If the atoms are moving, then they must also have a forward speed-momentum," Tera said.

"That's true," Chip said. "If you add up the s-momentum of each of the atoms, you'll produce a value we can call the **invo-atomic total s-momentum**."

"Grandpa Proge showed me that s-momentum is speed-based momentum," Pico said. "But wouldn't it be easier to simply multiply the invo-atomic average speed by the overall mass? See, 0.5 kg times 4.0 m/s will produce 2.0 kgm/s, or 2.0 ρ of s-momentum—that's a lot easier than adding up the s-momentum of every atom."



"Much easier," Tera affirmed. "But, earlier the total s-momentum was zero. If the s-momentum changed, then Newtonian motion fact #1 tells us the atoms in the nickel rock must've experienced some type of brief push—and that's an impulse!" Tera said.

Pico nodded, as she systematically clicked the data-input keys in her gloves. “That means when I repeatedly struck the nickel rock with the second rock, I produced an invo-atomic impulse of:”

$$invo\text{-}atomic\ im\Delta\rho = mv_{final} - mv_{initial}$$

$$invo\text{-}atomic\ im\Delta\rho = (0.5\ kg)(4\frac{m}{s}) - (0.5\ kg)(0\frac{m}{s})$$

$$\boldsymbol{invo\text{-}atomic\ im\Delta\rho = 2.0\ kg\frac{m}{s},\ or\ 2.0\ \rho,\ or\ 2.0\ momentums}$$

was written on their visor displays.

“The last line is showing that you exerted an invo-atomic impulse of 2.0 ρ,” Tera said. “And the last picture showed us, your impulse caused the atoms to move faster, in many different directions.”

“It’s just like the gems in my exercise game,” Pico said. (See *Murdered Energy Mysteries*, Chapter 102.)

Tera raised a thumbs-up, “And a faster invo-atomic average speed means the nickel rock is now slightly warmer than it was before you struck the rocks together.”

“Now we compare. The first time I applied an impulse, there was an increase in the exvo-atomic net velocity,” Pico recounted. “And this time the impulse caused a rise in the invo-atomic average speed.”

“That certainly sounds important,” Hectii’s melodic voice came from the speakers inside their helmets.

“I think we’ve discovered a new scientific fact,” Pico said. “Are you coming to join us?”

“What’re you going to call this new fact?” Hectii said.

Pico proposed, “How about the **impulse fact #1 of dual atomic motions?** It states, applying an impulse [momentum transfer] to an object can either cause an increase/decrease in the invo-atomic total s-momentum [relates to atomic speed and temperature], or the impulse can increase or decrease the object’s exvo-atomic net v-momentum [relates to human-level motion], or both.”

“That sounds stupendous, Pico!” Tera proclaimed. “Impulse can be measured, temperature can be measured, and motion can be measured.”

“That means our impulse fact #1 of dual atomic motions is a valid aspect of pure science,” Pico said. Pico turned her head to the right, placed her lips around a special straw, and sipped on her favorite carbonated beverage.

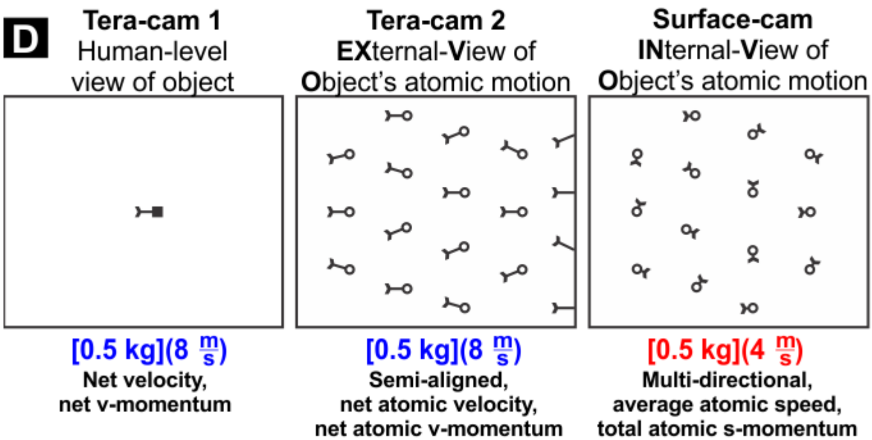
“Keep experimenting,” Hectii said. “I’m putting on my spacesuit. I’ll be there before you complete your next experiment.”

“It’s amazing how invo-atomic motion and exvo-atomic motion are all about where the camera is when you make the measurements!” Tera said.

"It also matters which equations you use," Pico said, as she deactivated her data-input gloves, reached out, and grabbed the nickel rock.

She checked to make certain the string was still firmly tied on the rock, pressed the auto-stabilize button on her spacesuit, and then reached back and gave the rock a hard throw. "Take a picture, quick!"

"Done," Chip said, as he placed three new pictures on their visor displays:



"Now the pictures look completely different from each other," Tera said excitedly.

Pico used the string to gently pull the rock back. "In the right picture, the surface-cam shows us, the invo-atomic average speed is still 4.0 m/s. The invo-atomic average speed hasn't changed. That means the temperature is the same as before I threw the rock."

“But the human-level velocity did change,” Tera said.

Pico nodded, activated her data-input gloves, and began keying, “That means I must’ve exerted an exvo-atomic impulse of:”

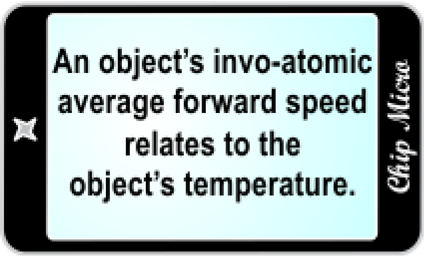
$$\textit{exvo-atomic im}\Delta\rho = mv_{final} - mv_{initial}$$

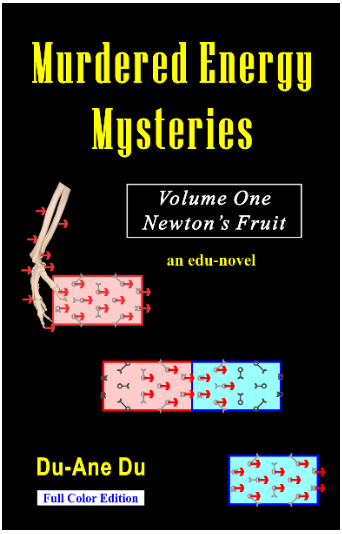
$$\textit{exvo-atomic im}\Delta\rho = (0.5\ kg)(8\tfrac{m}{s}) - (0.5\ kg)(0\tfrac{m}{s})$$

exvo-atomic im*$\Delta\rho$ *= 4.0 kg*$\frac{m}{s}$*, or 4.0* ρ*, or 4.0 momentums

appeared on their visor displays.

“This time your figures show an impulse of 4.0 ρ,” Tera said, a twinkle in her eye. “Once again, this experiment corresponds to our **impulse fact #1 of dual atomic motions**. When you apply an impulse (brief push) to an object, the impulse can either cause an increase/decrease in the invo-atomic speed—which relates to the temperature of the object…”





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"—or the impulse can produce an increase/decrease in the exvo-atomic net velocity of the atoms that make up the object," Pico finished with a flourish. "And exvo-atomic net velocity relates to human-level motion. It's the impulse fact #1 of dual atomic motions!"

"So far, we've learned that a brief push can have several different effects on a collection of cold atoms," Hectii paraphrased, as she glided into view.

"The scientific word for a brief push is an impulse," Pico said. "I wish we could think of another type of brief push to experiment with. If the Space-sci Sherlocks want to discover all the scientific facts, then we should attempt every possible type of experiment…"

* * *

Murdered Energy Mysteries seeks to increase understanding of the various forms of momentum and momentum transfer, as well as the various forms of energy and energy transfer. The lack of understanding on the part of the scientific community is substantial, and more research needs to be done.

—Du-Ane Du, author of the edu-novel *Murdered Energy Mysteries* (Amazon, Kindle, e-book 2018, paperback 2021.)

More information, visit www.Wacky1301SCI.com