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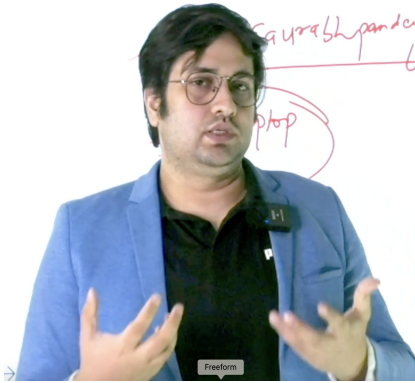
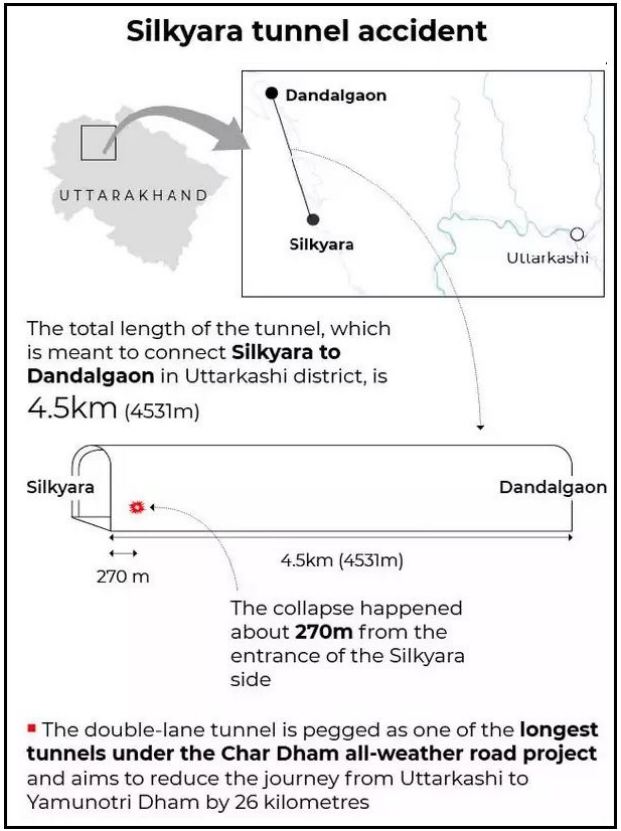


By saurabh Pandey

THE HINDU

MAPPING

- **Silkyara tunnel, planned to connect National Highway 134 in the Uttarkashi district of Uttarakhand, India..**



Shaping a response to the U.S.'s reciprocal tariffs

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President Donald Trump's announcement of reciprocal tariffs has come as a shock, though it is not a surprise. The new tariffs consist of two parts: the existing commodity-wise import tariff and an additional reciprocal country-wise common tariff for all goods. The resultant tariffs are country-wise as well as commodity-wise. The reciprocal tariffs announced are now on hold and limited to 10% for 90 days, except for China.

Calculation of reciprocal tariffs

The calculation of the reciprocal country-wise tariff is based on the following formula:

U.S. discounted tariff rate = (-1) * (1/2) * exports from U.S. - imports to U.S.)/imports to U.S.

The parametric assumptions are such that no individual tariff or import demand elasticities appear in this formula. The formula in substance is not the way to determine the tariff rate. In addition, the table presented by Mr. Trump has a column 'charged to the US'. This is misleading. This is not the tariff rate imposed by various countries. It is simply double the discounted reciprocal tariff rate. India's reciprocal tariff is worked out below using magnitudes of exports and imports in billion dollars for 2024.

India's discounted reciprocal tariff rate = (-1) * (1/2) * (41.8 - 87.4)/87.4 = 26.1% = 26%

This penal tariff rate is to be added to the tariff that is presently applicable for various commodities. The 26% rate would be a common additional element for all commodities. For countries that are not listed in the reciprocal tariff list, a floor rate of 10% has been announced. This will be added to their individual commodity-wise tariff rates.

Some commodities have been presently exempted from the levy of the additional discounted reciprocal tariff. These include steel/aluminum articles, autos/auto parts, copper, pharmaceuticals, semiconductors, lumber articles, bullion and energy and certain other minerals that are not available in the U.S..

Table

India's total exports of goods and exports of goods to the United States as % of GDP (current prices)

	Export of goods	Exports to the U.S.
FY22	13.4	2.4
FY23	13.5	2.3
FY24	12.1	2.1

Source (basic data): RBI and MoSPI

New Delhi's approach must be multi-pronged, keeping in mind that increasing imports from the U.S. will reduce the tariff rate on India

Calibrating India's response

We need to explore now what our reactions should be. As indicated in the *Table*, India's total exports of goods and its exports to the U.S. as a percentage of GDP are moderate.

India's exports to the U.S. are not only quite low but have also been falling in recent years. The impact of the additional 26% tariff would be small but different for different exported goods. India is certainly not a country that is heavily dependent on exports.

An analysis of major exports to the U.S. in terms of their share in total exports to the U.S. indicates that the main Indian exports that would be affected by the imposition of the additional 26% tariff would be electrical machinery, gems and jewellery, machinery and mechanical appliances, mineral fuels and articles of iron and steel. Pharmaceuticals are not yet subject to the additional tariff. Mineral fuels are refined oil products that are re-exported to the U.S. after processing in India. The impact on gems and jewellery is likely to be minimal as its demand is relatively inelastic. The main items that would therefore be affected include electrical machinery, machinery and mechanical appliances and made-up textiles. However, India's competitors in these three commodity groups such as China, Vietnam, Cambodia and Bangladesh have also been subjected to reciprocal tariffs which are higher than that of India. South Korea is also a competitor in electronic goods but has been subjected to a 25% reciprocal tariff, which is very close to that of India.

Some countries such as China have started levying reciprocal tariffs. However, this has elicited an aggressive response from the U.S., resulting in a revised overall tariff rate for China at 145%, which has been raised up to 245% for certain commodities. From India's angle this is not a good approach.

India's approach must be multi-pronged. An analysis of the major imports of India from the U.S. indicates that most of these are 'essentials'. Any levy of additional tariffs on them will make them more expensive. If India increases its imports from the U.S. wherever possible and advantageous, the penal reciprocal tariff rate on India will come down. For example, in the formula described above, if we increase the magnitude of India's imports from the U.S. by $25 billion, say, by substituting the import of petroleum from other sources to the U.S., India's reciprocal tariff rate will come down to 11.8%, just above the floor rate of 10%, making India far more competitive. This does not affect India's overall current account deficit. This results only in a change in the composition of India's oil imports basket. This may be even desirable.

India should speed up consultations with the U.S. trade authorities to work out a comprehensive trade arrangement taking into account the concerns of both countries. In the meanwhile, we should also watch out for 'dumping' in India by other countries such as China which are seriously affected.

WTO must take the lead

It is clear that the U.S. tariff initiative is only its opening gambit. Global trade and tariff structures would remain subject to considerable uncertainties in the near to medium term, which are bad for world trade and growth. As we move forward, we need to create a world trading system marked by low tariffs. The World Trade Organization should move strongly in this direction. Regional groupings are only a 'second best' solution which, however, must be pursued.

The views expressed are personal

Understanding President Trump's Reciprocal Tariffs

Introduction to Reciprocal Tariffs

- President Trump's announcement of reciprocal tariffs created a stir in the global trade community.
- The tariffs are divided into two parts: existing commodity-wise import tariffs and an additional reciprocal country-wise common tariff.
- These tariffs are both country-specific and commodity-specific, leading to complex trade implications

Breakdown of the New Tariffs

- Existing Commodity-wise Import Tariff: Standard tariffs applied to specific goods entering the U.S.
- Additional Country-wise Common Tariff: A uniform tariff rate for goods from specific countries, altering trade dynamics.
- The 10% Hold for 90 Days: Temporary measure allowing countries to adjust and negotiate, but adds market uncertainty

Calculating Reciprocal Tariffs

The Formula Explained:

U.S. discounted tariff rate = (-1) * (1/2) * (exports from U.S. – imports to U.S.)/imports to U.S.

Misleading Information in Tariff Tables: The table presented by Trump included a misleading column labeled ‘charged to the US.’

India's Discounted Reciprocal Tariff Rate

- How It Affects Indian Exports: An additional 26% tariff on various commodities, though India's exports are not heavily reliant on a few key sectors.
- Commodities Exempt from Additional Tariffs: Exemptions include steel, aluminum articles, autos, pharmaceuticals, and energy

Analyzing India's Response

- Current Export Trends: India's exports to the U.S. are declining, complicating the situation.
- Major Exports Impacted: Electrical machinery, gems and jewelry, and machinery are the main exports affected

Strategic Approaches for India

- Increasing Imports from the U.S.: A strategy to lower the reciprocal tariff rate.
- Importance of Trade Consultations: Engaging with U.S. trade authorities to address mutual concerns.

The Role of the WTO

Need for a Global Trading System: The WTO should lead in creating a system with low tariffs to stabilize global trade.

Conclusion

President Trump's reciprocal tariffs have significant implications for global trade, especially for countries like India.
Long-term effects could reshape trade dynamics, necessitating dialogue for a stable trading environment

How China is fighting U.S. tariffs

The most unexpected development following the launch of Trump's trade war has been China's retaliation. Its long-term strategy of hedging against risk, from the actions of an aggressive trade partner, has enabled the country to counter one of the worst trade-related escalations in modern history

ECONOMIC NOTES

Biswajit Dhar

In the three months since U.S. President Donald Trump launched his "America First" trade policy, weaponising trade to extract concessions from his partner countries, there are indications that it could bring the global economy to its knees. "Reciprocal tariffs" were proposed as a key component for eliminating what Mr. Trump perceived as "unfair trade practices" of partner countries.

But on April 9, the day this instrument was to take effect, President Trump did a turnaround and the implementation of "reciprocal tariffs" was postponed by 90 days for all 57 target countries, except China.

The objective of the U.S. administration is to compel its trade partners to negotiate bilateral agreements within the stipulated period, through which they offer concessions to American stakeholders. The Trump administration's expectation is that trade partners would then be forced to reduce their trade deficits vis-à-vis the U.S., an overarching trade policy objective of the new President.

A trade war

China had declared right from the beginning, even as the U.S. President was laying down the contours of this aggressive trade policy, that it would challenge the decision to impose "reciprocal tariffs". And as anticipated, China announced its decision to impose retaliatory tariffs equivalent to the 34% "reciprocal tariff" that it faced, in response to which Mr. Trump imposed an additional tariff of 50%, raising the overall tariff burden to 104%. China then escalated the trade war by imposing 125% tariffs on all its imports from the U.S., which led to the White House increasing tariffs again to 145%.

However, in the midst of this escalation, Washington tacitly admitted to the potential impact these tariffs would bring by exempting a number of critical electronic goods, including computers, laptops, smartphones, and semiconductor devices, from such tariffs, reflecting the overwhelming dependence of the U.S. on import of these products. There is still confusion about the same in the Trump administration, which was evident when Commerce Secretary, Howard Lutnick, informed that tariffs on electronics products would be included within semiconductor tariffs in a "month or two", only to be contradicted by the President, who declared that these tariffs would be imposed sooner. The "America First" trade policy is causing much chaos, with its adverse implications impossible to gauge at this juncture.

Two sets of issues arise as Donald Trump's trade war continues to hold the global economy to ransom. First, can the 90-day pause in the implementation of "reciprocal tariffs" provide the Trump team opportunities to stitch together at least a few agreements that would allow the "dealmaker" President to wax eloquent about his accomplishments? Secondly, what explains Xi Jinping's extraordinary defiance against Donald Trump's all-out attempt to corner Beijing? And more importantly, does Mr. Xi have a strong trump card with which he can effectively counter Donald Trump and his "America First" trade policy?

The U.S.'s negotiating agenda

Though Donald Trump's decision to pause the implementation of "reciprocal tariffs" to push his trade partners to conclude bilateral deals made immediate headlines, the move was part of a strategy that the President's advisers had worked out well before he took office. Stephen Marin, chair of the U.S. council of economic advisers, had argued in a paper published immediately after Donald Trump's election as President that "tariffs create negotiating leverage for incentivising better terms from the rest of the world on both trade and security terms. America would encourage other nations to move to lower tariff tiers, improving burden sharing". Peter Navarro, senior counselor for trade and manufacturing, explained that the 90-day pause was "part of a calculated negotiating tactic", and "a demonstration of Trump's signature dealmaking style".

These explanations would no doubt be immensely satisfying for the President, but the question is whether trade deals can actually be re-negotiated with at least a few targeted countries. This seems improbable for at least two reasons. Under the Trump administration, the U.S.' negotiating approach has undergone a major change, as the *de jure* trade negotiator, the U.S. Trade Representative (USTR) is no longer in charge of negotiations. Peter Navarro revealed that Trump, "the boss, is going to be chief negotiator. Nothing is done without him looking very carefully at it." When the head of the government of the world's largest economy decides to micro-manage trade deals, it is possibly safe to conclude that negotiations would be a non-starter.

A second problem for the U.S. is that it has a gargantuan negotiating agenda, a peek into which was provided in a recent USTR report – the National Trade Estimate Report on Foreign Trade Barriers. This report highlights "significant foreign barriers to U.S. exports, U.S. foreign direct investment and U.S. electronic commerce" in India and 56 other countries. It identifies "unfair trade practices [undermining] U.S. exporters' competitiveness and, in some cases, [preventing] U.S./ goods from entering the foreign market entirely". It can, therefore, be argued that unless these "unfair trade practices" identified by the USTR are removed, the U.S. President's aspiration of "Making America Great Again" cannot be realised.

If Trump has to secure this grand bargain, India, for instance, would have to open its agricultural markets for U.S. agri-business, lower its agricultural subsidies, discontinue its public distribution system, and amend its Patents Act risking the future of India's generic pharmaceutical companies providing affordable medicines. India would also have to discontinue policies that the U.S. has repeatedly red-flagged, including data localisation, and regulations on genetically modified crops and dairy products. Would India and other targeted countries allow Donald Trump to coerce them into amending their laws and policies to "clinch" a trade deal?

China's strategy

The most unexpected development following the launch of Trump's trade war has been China's retaliation. In his first term as President, Mr. Trump had forced China to ink an enforceable Economic and Trade Agreement in 2020, acceding to several of his demands. But over the past few years, the nature of the U.S.-China trade relationship has changed drastically, which could explain the push back from the world's second largest economy. In 2018, the U.S. was China's largest export market with a 19.2% share. But over the past six years, China reduced this figure to below 15% and in the first quarter of 2025, only 13.5% of China's exports reached the U.S. At the same time, China has diversified its export markets, with ASEAN emerging as the most significant destination. Several major economies, including India, Vietnam, and the Russian Federation, have seen an appreciable increase of the Chinese footprint in their economies. This is a remarkable instance of hedging against risk, from the actions of an aggressive trade partner, which has enabled China so far to counter one of the worst trade-related escalations in modern history.

By diversifying its exports as a part of its defensive strategy, China is in a position to leverage its two significant strengths to force the hands of its aggressor. The first is China's control over the rare earth market, accounting for 92% of global output. China has already shown its hand by imposing export restrictions on seven types of rare earth minerals in the past few days.

A second advantage for China is its position as the second largest holder of U.S. Treasury bonds, but in recent years, it has been gradually selling its holdings. Since 2018, China has reduced its holdings from $1.2 trillion (22% of the total) to $761 billion (less than 9%) in January 2025 (see Charts). Though it seems unlikely at this juncture that China would take the risk of dumping its holding to challenge the U.S., any further escalation of the trade war can alter the situation.

Given this grave risk of economic disruption, major economies must coordinate their efforts to ensure that the U.S. President abandons unilateralism, and reposes his faith in multilateralism as the way forward.

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Both China and Japan lowered their holding of U.S. treasury bonds over the years, although Japan's holding increased slightly since 2023. China's has fallen lower than that of Japan. As of January 2025, China's holding reduced to $761 billion and just 8.9% of the overall treasury bonds. The corresponding numbers for Japan are $1079.3 billion and 12.7% respectively

1 In 2018, the U.S. was China's largest export market with a 19.2% share. But over the past six years, China reduced this figure to below 15% and in the first quarter of 2025, only 13.5% of China's exports reached the U.S.

2 China continues to remain as the second largest holder of United States Treasury bonds. However, in recent years, it has been gradually selling its holdings

Chart 1: China and Japan's holdings in U.S. treasury bonds (in $ billion)

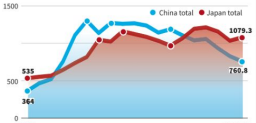
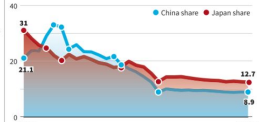


Chart 2: China and Japan's shares of total U.S. treasury bonds (in %)



THE GIST

- China had declared right from the beginning, even as the U.S. President was laying down the contours of this aggressive trade policy, that it would challenge the decision to impose "reciprocal tariffs".
- Though Donald Trump's decision to pause the implementation of "reciprocal tariffs" to push his trade partners to conclude bilateral deals made immediate headlines, the move was part of a strategy that the President's advisers had worked out well before he took office.
- By diversifying its exports as a part of its defensive strategy, China is in a position to leverage its two significant strengths to force the hands of its aggressor.

China’s Strategy: Navigating the Trade War Landscape

Introduction to the Trade War

- The trade war began during Donald Trump’s presidency with tariffs and retaliatory measures.
- Initially a straightforward economic battle, the dynamics have shifted over time.
- China has shown resilience and adaptability against U.S. actions.

The Shift in U.S.-China Trade Relations

- Over five years, the trade relationship has transformed significantly.
- In 2018, the U.S. was China’s largest export market with a 19.2% share.
- By 2025, this share dropped to 13.5%.

Historical Context: The Trade War Begins

The decline in U.S. market share is a result of strategic diversification by China.

Changes in Export Markets

China has diversified its export markets, reducing reliance on the U.S.

The Decline of U.S. Market Share

Strategic reduction in reliance on the U.S. as a primary export destination.

Rise of ASEAN and Other Markets

ASEAN countries, India, Vietnam, and Russia have become significant players in China’s export strategy.

Diversification of Exports

Spreading exports across multiple markets to reduce vulnerability.

Control Over Rare Earth Elements

China dominates the rare earth market, accounting for 92% of global output.

The Importance of Rare Earths

Crucial for high-tech industries, providing China with a powerful bargaining chip.

Recent Export Restrictions

China imposed restrictions on seven types of rare earth minerals.

U.S. Treasury Bonds: A Double-Edged Sword

China’s holdings of U.S. Treasury bonds play a significant role in its strategy.

China’s Holdings Over Time

Holdings reduced from $1.2 trillion in 2018 to $761 billion.

Potential Risks of Dumping Bonds

Dumping bonds could destabilize the U.S. economy and have global repercussions.

The Global Economic Landscape

The impact of these strategies extends beyond the U.S. and China.

The Need for Multilateralism

Major economies must encourage the U.S. to embrace multilateralism.

Coordinated Efforts Among Major Economies

Collaboration can mitigate economic disruption and foster stability.

Conclusion

- China’s strategy in the trade war showcases adaptability and resilience.
- By diversifying export markets and leveraging strengths, China thrives amidst adversity.
- Cooperation and multilateralism are crucial in the shifting global economic landscape

Easter treat

Humbolt Penguins enjoy a treat ahead of the Easter weekend on Tuesday in Edinburgh, Scotland. The Five Sisters Zoo outside Edinburgh is home to more than 160 different species from around the world, including rescued animals. GETTY IMAGES

HUMBOLDT PENGUIN } *Spheniscus humboldti*

DESCRIPTION: This medium-sized penguin grows to be about 26 to 28 inches long and weighs about 10.4 pounds. It has blackish-gray upperparts, white underparts, a black breast band, and a black head with white stripes running from the eyes around the ear-coverts to join beneath the chin. The bill is mostly black, but light-pink at its base. Juveniles have dark heads and no breast band.

HABITAT: This penguin nests on islands and rocky coasts and feeds in surrounding waters. Its habitat is highly influenced by the cold, nutrient-rich Humboldt Current flowing northward from Antarctica, which is vital to the productivity of plankton and krill and fosters fish abundance.

HUMBOLDT PENGUIN

Spehiscus Humboldti

KG 3.3 - 5

Average weight:
between 3.3 kg and 5 kg

Size
50-75 cm

Average lifespan:
15-20 years

Location

It is endemic to the Humboldt current; It nests on the western coast of South America, from Peru to Chiloé archipelago in Chile.

designed by @RamiroRodriguezArt

VS

The Islotes de Puñihuil Natural Monument on Chiloé Island is famous for being the only known place where the Humboldt and Magellanic penguins share the breeding site.

MAGELLANIC PENGUIN

Spehiscus Magellanicus

KG 2.5 - 3

Average weight:
between 2.5 kg and 3 kg

Size
35-40 cm

Average lifespan:
20-25 years

Location

Peninsula Valdes
Punta Tombo
Tierra del Fuego Is.
Chiloe Island
Atlantic Coast in Patagonia

RANGE: The Humboldt penguin lives along the coasts of Chile and Peru in the southeastern Pacific Ocean.

MIGRATION: When not raising chicks, these penguins have been known to travel long distances at sea to find food, especially in recent years as prey species become increasingly scarce.

BREEDING: Humboldt penguins can breed at any time of year, usually digging burrow-like nests among piles of guano in caves and along cliffs. Females lay one or two eggs, which are incubated for about 40 days by both parents, but one chick often dies of starvation. Chicks fledge after about 70 to 90 days and molt into adult feather about a year later.

LIFE CYCLE: This penguin's lifespan is about 20 years.

- **FEEDING:** Humboldt penguins feed primarily on fish, especially anchovies, herring and smelt.
- **THREATS:** Humboldt penguin populations were first devastated by the mining of guano deposits — in which the species prefers to nest — for fertilizer. Through the mid-20th century, the penguin appeared to be recovering from this early threat. But changes in ocean currents and temperatures in the Pacific Ocean, apparently driven by global warming, appear to be a grave threat to the species' survival; El Niño southern oscillation events reduce the upwelling of cold, nutrient-laden waters to reduce penguin prey and overall productivity. This penguin is also imperiled by intense commercial fishing and oil pollution.

The view inside the Sterkfontein caves within the Cradle of Humankind in Krugersdorp on Tuesday. AFP

S. Africa's 'cradle of humankind' caves reopen to public

Agence France-Presse
KRUGERSDORP

Seated on sandbags in a knee-deep grid dug in South Africa's Sterkfontein caves, where one of our earliest ancestors was found, Itumeleng Molefe swept ancient soil into a blue dustpan, each brushstroke hunting for hidden clues.

Nearby, visitors marvelled at the weathered limestone rocks hanging from the ceiling of the caves, millions of years old.

Located 50 km northwest of Johannesburg, the caves closed nearly three years ago due to flooding and reopened Tuesday with a new experience bringing tourists closer to the scientific action.

The complex is housed within the Cradle of Humankind World Heritage Site, a rich source of artefacts for palaeontologists.

"My aim is to find important bones here," said Molefe. His most prized find since joining the excavation team in 2013 was an early human hand bone. His father was part of the team that uncovered South Africa's most famous find, a skeleton dubbed "Little Foot", in the caves. Deriving its name from the size of the bones first discovered in the 1990s, it is the most complete specimen of a human ancestor yet discovered, estimated to be between 1.5 and 3.7 million years old.

"This reopening represents a significant evolution in how we share the story of human origins," said Nithaya Chetty, dean of the University of the Witwatersrand faculty of science, which manages the caves and the nearby museum. "Visitors now have unique opportunities to engage with active live science and research, all happening in real time," said the professor.

Exploring Sterkfontein

Introduction to Sterkfontein

Location: Situated in Gauteng province, 40 km northwest of Johannesburg.

Significance: Known for its limestone caves and importance in paleoanthropology.

Accessibility: Easily reachable from Johannesburg, though closed to visitors as of 2024.

The Geological Marvel of Sterkfontein

Formation: Caves formed over millions of years through erosion and sedimentation.
Ecosystem: Home to diverse wildlife, including the `Belonogaster petiolata` wasp

Paleoanthropological Importance

Discoveries: Numerous early hominin remains found.
- **Australopithecus**: Early ancestors, bipedal hominins.
- **Early Homo:** Transition to modern humans.
- **Paranthropus**: Known for robust cranial features.

The Cradle of Humankind

UNESCO Status: Sterkfontein is not just another cave; it’s a South African National Heritage Site and was declared a UNESCO World Heritage Site in 2000

Nearby Sites: Includes Swartkrans and Kromdraai, forming a rich archaeological landscape

Underwater heavyweight mantis shrimp also packs a natural energy shield

As the dactyl club of a mantis shrimp strikes its prey, it displaces the surrounding water and forms small low-pressure zones where the water's density drops so much that it turns into vapour; when the resulting void collapses, it releases high-frequency shockwaves — yet the animal remains unharmed. How?

Sanjukta Mondal

The mantis shrimp is a colourful, 10-cm-long resident of the ocean whose appearance belies its reputation as one of the most fearsome predators on the planet.

These unassuming crustaceans use a hammer-shaped appendage called the dactyl club to strike their prey at a blistering 23 m/s (about 50 times faster than the blink of an eye), smashing into the poor creature's body like a bullet from a gun fired point-blank. The strike releases enough energy to send small shockwaves through the surrounding water.

But the thing about guns is that every bullet fired has a recoil. It's Newton's third law of motion. If a firearm is not securely braced against the body to absorb it, the sudden backward motion can lead to severe injuries.

Yet despite striking prey hard enough to produce shockwaves, the mantis shrimp remains unharmed. How is this possible?

Research into the dactyl club can be applied to materials that can protect personnel from shockwaves and sound. CREMBOC (CC BY-SA)

Lasers reveal a shield

A team of researchers from the US and France found the answer in a specialised microstructure in the mantis shrimp's club. They found that this structure was capable of phononic shielding – a unique ability that allows it to blunt the flow of acoustic waves and thus weaken the recoil the mantis shrimp has.Their findings were reported in February in *Science*.

The team fired laser pulses at the microstructure in a rapid sequence that illuminated its response at less than one-billionth of a second at a time. They followed this up with numerical simulations.

"People have looked at the material structure under a microscope but haven't explored the dynamic mechanical behaviour, especially how it responds to wave propagation," Maroun Abi Ghanem, the study's coauthor and a researcher at the Centre National de la Recherche Scientifique, France, said.

"We looked into this behaviour by sending waves through the structure and analysed how they interacted with the material."

Triggering implosions

The dactyl club of a mantis shrimp stores its energy in spring-like elastic structures held together by latch-like tendons. When the latch is released, the club is released. As it moves to deliver its punch, it displaces the surrounding water and forms small low-pressure zones. Inside these zones, the water's density drops so much that it turns into vapour, leaving behind a bubble.

When these bubbles collapse due to the pressure of the surrounding water, they release a considerable amount of heat and shockwaves of very high frequencies, up to hundreds of megahertz.

Thus, each dactyl-club punch delivers two blows: one from its own punch and the other from the collapsing bubbles, and together they are capable of breaking the tough shells of clams, mussels, and other crustaceans.

The dactyl club has a hierarchical design – a fine-tuned blend of mineral and organic materials arranged in three layers. The outermost impact surface is made of a thin but hard inorganic material called hydroxyapatite, which distributes the recoil and prevents it from accumulating at one point. Beneath it, the impact layer and the periodic region contain biopolymer fibres arranged in a pattern that can withstand repeated high-intensity impact without incurring significant damage.

Previous studies have explored the club's material structure and impact resistance. The new study went a step further to check whether the periodic architecture of the materials enhances their mechanical performance.

It does. The team found that the internal arrangement of the microstructure serves as a phononic bandgap: a structure that prevents energy waves of certain frequencies from passing through, or at least significantly attenuates them, Horacio Espinosa, a study coauthor and professor of mechanical and biomedical engineering at Northwestern University in Illinois, the US, said.

> We are working on biomimetic structures inspired by the architecture of the mantis shrimp with a focus on wave trapping

'An incredible example'

To mimic the ultrafast club strike in the laboratory, the team used a pair of pulsed lasers that emit very short flashes of light: one to generate energy waves on the material surface and the other to detect them.When the laser was directed onto a material, it absorbed the light and induced thermoelastic expansion, i.e., heating and expanding the material. This generated a stress wave on the surface, like a miniature earthquake. The team tracked the wave's movement through the shrimp's club to understand energy transfer in the material.

The readings helped researchers draw dispersion diagrams – plots that revealed the bandgaps, or specific frequency ranges, where waves couldn't pass through or were considerably weakened. The appearance of this pattern in the data indicated to the team that the mantis shrimp used phononic shielding to protect itself from the recoil.

"What's even more fascinating is that our findings suggest the club's structure not only resists these intense forces but may also be fine-tuned to control how shock waves propagate through it," Espinosa said. "This dual role of structural robustness and wave manipulation is an incredible example of nature optimising materials at multiple levels."

Here all along

For a long time, scientists believed that materials that could guide the flow of energy in particular ways could only be created in the lab, not in the wild. Such materials are called metamaterials: they have specially tailored geometries to achieve these effects. The new finding about the mantis shrimp stands to change this belief. Nature always had metamaterials. The study's findings can also be applied to develop synthetic sound-filtering materials for use in protective gear, such as earmuffs for soldiers. They could also inspire new approaches to reducing blast-related injuries in the army and sports, the researchers said in a statement.

"We are working on biomimetic structures inspired by the architecture of the mantis shrimp with a focus on wave trapping," Abi Ghanem said. "We are interested in understanding how the structures trap waves, exploring what we can do with this trapped energy, and if it is possible to convert the trapped energy into another form."

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THE GIST

The mantis shrimp uses a hammer-shaped appendage to strike its prey at a blistering 23 m/s, smashing into the creature's body like a bullet fired from a gun at point-blank range

Researchers found a specialised microstructure in the shrimp's club. This structure was capable of phononic shielding — allowing it to blunt the flow of acoustic waves and thus weaken recoil

For a long time, scientists believed that materials that could guide the flow of energy could only be created in the lab. These are called metamaterials. The new finding stands to change this. Nature always had metamaterials

The mantis shrimp

- The mantis shrimp is a colourful, 10-cm-long resident of the ocean whose appearance belies its reputation as one of the most fearsome predators on the planet.
- These unassuming crustaceans use a hammer-shaped appendage called the dactyl club to strike their prey at a blistering 23 m/s (about 50 times faster than the blink of an eye), smashing into the poor creature's body like a bullet from a gun fired point-blank. The strike releases enough energy to send small shockwaves through the surrounding water.

- Researchers found a specialised microstructure in the shrimp’s club. This structure was capable of phononic shielding — allowing it to blunt the flow of acoustic waves and thus weaken recoil
- For a long time, scientists believed that materials that could guide the flow of energy could only be created in the lab. These are called metamaterials. The new finding stands to change this. Nature always had metamaterials

BIG SHOT

A great cormorant in the Camargue marshes near Arles, France, on February 27. Hunting with lead shells has been banned in the French wetlands since 2006, yet a study published on April 15 in *Conservation Science and Practice* showed that lead poisoning of waterbirds has not decreased. AFP

The **great cormorant** (***Phalacrocorax carbo***),

- **The great cormorant (*Phalacrocorax carbo*), known as the black shag or kawau in New Zealand, formerly also known as the great black cormorant across the Northern Hemisphere, the black cormorant in Australia, and the large cormorant in India, is a widespread member of the cormorant family of seabirds.**
- **It breeds in much of the Old World, Australasia, and the Atlantic coast of North America.**
- **The great cormorant often nests in colonies near wetlands, rivers, and sheltered inshore waters.**

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