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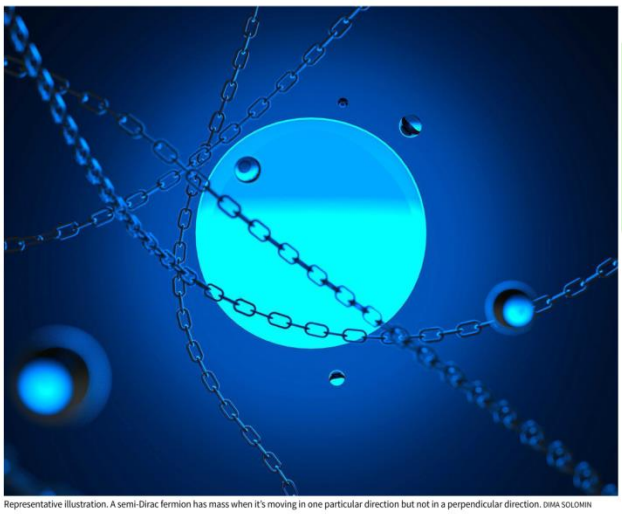
Physicists are discovering new and unusual subatomic particles, like semi-Dirac fermions, which help expand our understanding of matter and the laws of nature.

'Strange' particle possesses mass when moving in one direction, not another

Physicists stress subatomic particles to enable discovery. The CERN supercollider smashes billions of protons head on with as much energy as at the dawn of the universe. Recently, researchers used a magnetic field 2.7 lakh times stronger than the Earth's to discover semi-Dirac fermions

Vasudevan Mukunth



Representative illustration. A semi-Dirac fermion has mass when it's moving in one particular direction but not in a perpendicular direction. DIMA SOLOMIN

Since the start of the 20th century, physicists have discovered a veritable zoo of subatomic particles. Matter can be both wave and particle. If you take the particle route, these subatomic particles are what you could say the universe and everything in it is made of. There are many ways to further categorise them.

A common one is as fermions and bosons: fermions make up matter and bosons mediate the forces between matter. For example, electrons and protons are fermions whereas photons are bosons.

Fermions can be further classified as Dirac or Majorana fermions. Dirac fermions are fermions that may or may not have mass but are always different from their anti-particles. Majorana fermions are fermions that are also their own antiparticles (neutrinos are suspected to be Majorana fermions).

The zoo smells funny

Even if these distinctions seem too fine, they're of considerable interest to physicists. They know something's up in the subatomic zoo. Some animals that should obviously be there are missing, like the particle for the force of gravity. Some animals are much heavier than they should be (Higgs bosons and neutrinos). One enclosure, dark matter, remains empty even though physicists have been looking for it under every rock and leaf. Their knowledge of quite a few animals is just incomplete or at odds with what they studied in school. There's a lot of work left if the zoo is to be a fully understood place without any surprises.

To simply this task, physicists have developed a common theory that collects all these animals under a single, unified description, called the Standard Model (SM) of particle physics. Physicists can explore 'new physics' in terms of whether it agrees or disagrees with the SM. Right now it's like a big jigsaw puzzle with a few important pieces missing. If physicists find a new piece in their calculations or their particle collider experiments, they can check if it fits into the puzzle. If it doesn't, maybe the puzzle itself needs to be changed.

In a sense, grouping fermions into fine categories is an exercise in meticulously cataloguing the exact shapes of the puzzle's pieces.

This way, if physicists find a piece whose shape is new even in a very small way, they stand to make a big update.

Something strange comes this way

A particle as it exists in the wilderness of space is slightly different from a particle that exists inside solids and liquids. "In condensed-matter physics, every material can behave like a new universe," IIT Kanpur assistant professor Adhip Agarwala said.

"Here strange particles can arise and be experimentally detectable, which are otherwise not usually seen in three dimensions."

For example, two-dimensional materials can host particles called anyons whose properties lie somewhere between those of fermions and bosons.

Recently, researchers at Columbia University and Pennsylvania State University reported finding another strange particle called a semi-Dirac fermion.

Dirac fermions have mass and aren't their own anti-particles. A semi-Dirac fermion has mass when it's moving in one particular direction but not in a perpendicular direction. This unusual characteristic, which makes semi-Dirac fermions very exotic, is the result of the fermion's interaction with the electric and magnetic forces acting on it in certain materials.

The semi-Dirac fermion reported in the experiment is technically a quasiparticle. A quasiparticle is a clump of particles or energy-packets that, in some given conditions, behaves like a single particle. Protons are quasiparticles, for example: each proton is made of three quarks and the gluons holding them together. In most settings, what separates particles from quasiparticles is a distinction without a difference. If a quasiparticle is a fermion, it's a fermion in the same way an electron is a fermion.

Location, location, location

When trying to find puzzle pieces with new shapes, physicists need to know exactly which material to look in or they could be searching forever. This is much like in life sciences research. By studying the 1-mm-long roundworm *Caenorhabditis elegans*, for example, scientists have discovered many fundamental principles of biology and have won four Nobel Prizes so far. The locale of choice in the new study was a layered crystalline material called zirconium silicon sulphide (ZrSiS).

When a magnetic field is applied to a metal, the electrons inside are accelerated along a curved path. (The protons are confined to the atomic nuclei.) The energy of these electrons is called cyclotron energy.

In the metal, the cyclotron energy increases linearly with the strength of the magnetic field. This relationship can be denoted as B^1, where B is the strength of the magnetic field and 1 is the exponent to which it is raised. In graphene, which is a single-layer sheet of carbon atoms linked together, the cyclotron energy increases in step with the square-root of the magnetic field strength. The relationship is thus $B^{1/2}$. In ZrSiS, the researchers found the cyclotron energy to increase as $B^{2/3}$. Previous theoretical research has found that this scaling factor is a unique signature of semi-Dirac fermions.

'The same laws of nature'

The researchers didn't land up at ZrSiS by accident; the locale is crucial, after all. Physicists in general knew for some time that there could be semi-Dirac fermions in graphene. But to reveal the quasiparticles' presence, they had to first stretch graphene to such a degree that they often ended up tearing it apart. An older study also revealed some unusual electronic properties in zirconium silicon selenide (ZrSiSe), which has a similar structure, in the presence of a magnetic field.

The authors of the present study put these and other indications together and decided to look for semi-Dirac fermions in ZrSiS – and voila.

"This shows the magic of condensed matter physics, where every material, be it graphene or ZrSiS, can host exotic particles that one can discover in table-top experiments – whereas to discover subatomic particles we often need huge colliders," professor Agarwala said. "It is the same laws of nature that guide them all."

Physicists have developed a common theory that collects subatomic particles under a unified description, called the Standard Model. Physicists can explore 'new physics' in terms of whether it agrees or disagrees with the SM

The zoo expands

Physicists regularly subject subatomic particles to extreme conditions to elucidate the laws of nature at the edge of reality. The Large Hadron Collider in CERN in Europe smashes billions of protons head on with as much energy as there was just 0.000000000000004 seconds after the Big Bang. Even in the present study, the researchers subjected ZrSiS crystals to a magnetic field of up to 17.5 tesla – about 270,000-times stronger than the earth's magnetic field.

The researchers have said they plan to continue their studies calculations to understand more about ZrSiS and try to explain some other unusual electronic behaviour they observed in their study.

The finding is a new animal in the particle zoo. As one more enclosure awaits its occupant and zoo authorities fill out the paperwork, the question arises: how will it change the zoo?

(The author thanks IISc assistant professor Nirmal Raj for feedback. mukunth.v@thehindu.co.in)

Understanding Subatomic Particles

- Subatomic particles are the basic building blocks of everything in the universe.
- **These particles are divided into two main categories:** fermions and bosons.Fermions, like electrons and protons, are the particles that makeup matter.

- Fermions are what form the structure of atoms and, ultimately, all matter around us.
- Bosons, such as photons, help in carrying forces between different particles of matter.
- Bosons play a key role in forces like light and gravity, helping particles interact.
- Understanding these particles helps explain how everything in the universe functions.
- Both fermions and bosons are essential in shaping the physical world we live in.

Types of Fermions

- Fermions are classified into Dirac fermions and Majorana fermions.
- Dirac fermions may or may not have mass and are different from their antiparticles.
- Majorana fermions are their own antiparticles, with neutrinos suspected to belong to this category.

Challenges in Particle Physics

- Physicists face challenges in identifying missing particles, such as those responsible for gravity.
- Some particles, like Higgs bosons and neutrinos, are heavier than expected.
- Dark matter remains a mystery, as its presence has not been directly detected.
- The Standard Model (SM) organizes known particles but has gaps that need filling.

Discovery of Semi-Dirac Fermions

- Semi-Dirac fermions are unique particles with mass in one direction but not in another.
- They were discovered in zirconium silicon sulphide (ZrSiS), a crystalline material.
- These particles behave as fermions under specific electric and magnetic forces.

Role of Condensed Matter Physics

- Condensed matter physics allows the discovery of exotic particles in smaller, controlled experiments.
- Materials like graphene and ZrSiS act as hosts for particles like semi-Dirac fermions.
- This field provides valuable insights without requiring massive particle colliders.

Future Research and Implications

- Researchers aim to explore ZrSiS further to understand its unusual properties.
- Each discovery helps expand the "particle zoo" and reveals new aspects of the universe.
- Understanding these particles brings physicists closer to uncovering the fundamental laws of nature.

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Ques : Examine the significance of semi-Dirac fermions in advancing our understanding of subatomic particles and condensed matter physics. (150 Words /10 marks)

Page 07 : Prelims Fact

A SpaceX Falcon 9 rocket launched two lunar landers: Blue Ghost by Firefly Aerospace (U.S.) and Resilience by ispace (Japan).

- The launch took place from Kennedy Space Center, Florida, on Wednesday, marking a significant step for private sector involvement in space exploration.

Mission Objectives

- The goal is to achieve soft landings on the moon, building on the success of Intuitive Machines, the first company to land successfully on the moon in 2022.
- The mission is part of NASA's Commercial Lunar Payload Services (CLPS) program, which aims to reduce costs and promote a lunar economy by partnering with private companies.

Details of the Landers

- **Blue Ghost:**
  - Launched first, will take 45 days to reach the moon.
  - It will land near Mons Latreille, a volcanic feature on the moon's northeast side.
  - Carries 10 NASA instruments for scientific research, including studying lunar dust, magnetosphere, and the moon's interior.
- **Resilience:**
  - Will take 4-5 months to reach the moon's Mare Frigoris, located on the far north side.
  - It carries a micro rover, 'Tenacious', designed to scoop moon dust and send back images.

Challenges

- Both landers must navigate difficult terrain with craters and boulders, relying on thrusters for a soft landing due to the lack of an atmosphere.

A SpaceX Falcon 9 rocket launches with the Blue Ghost lunar lander and ispace's Resilience lander from the Kennedy Space Center, Florida, U.S., on Wednesday. REUTERS

U.S., Japan moon landers launch on single rocket

Agence France Presse

One rocket, two missions: lunar landers built by U.S. and Japanese companies launched their "rideshare" to the moon on Wednesday, showcasing the private sector's growing role in space exploration.

On board the SpaceX Falcon 9 rocket that took off from the Kennedy Space Center in Florida were Firefly Aerospace's Blue Ghost and ispace's Resilience from Japan, which will also deploy a micro rover.

Both uncrewed missions aim to build on the success of Texas-based Intuitive Machines, which last year became the first company to successfully touch down on the Earth's celestial neighbour.

Until recently, soft landings on the moon were achieved only by a handful of well-funded national space agencies, starting with the Soviet Union in 1966.

Now, however, several emerging U.S. companies are attempting to replicate this feat under NASA's experimental Commercial Lunar Payload Services (CLPS) programme, designed to cut costs and stimulate a lunar economy.

The U.S. plans to establish a sustained human presence on the moon later this decade under the Artemis programme, leveraging commercial partners to deliver critical hardware at a fraction of the cost of government-led missions.

On the Japanese side, Tokyo-based ispace's first attempt to land on the moon ended in an unsalvageable "hard landing" in April 2023.

Blue Ghost is stacked atop Resilience inside the Falcon 9, SpaceX executive

The U.S. plans to establish a sustained human presence on the moon under the Artemis programme, leveraging commercial partners to deliver hardware at a fraction of the cost

Julianna Scheiman said, and will be deployed first, followed by Resilience nearly 30 minutes later.

The two spacecraft have different timelines for reaching the moon. Blue Ghost aims to complete its journey in 45 days, gradually lifting its orbit around the Earth before entering lunar orbit and touching down near Mons Latreille, a volcanic feature on the moon's northeast near side.

"With 10 NASA instruments on this flight, we're conducting scientific investigations... from characterising the earth's magnetosphere to understanding lunar dust and the moon's interior structure and thermal properties," NASA scientist Maria Banks said.

Blue Ghost also carries technology demonstrations focused on navigation and computing in the moon's harsh radiation environment.

Meanwhile, Resilience will take four to five months to reach its destination in Mare Frigoris, on the moon's far north.

Its payloads include scientific instruments, but the centrepiece is 'Tenacious,' a micro rover developed by ispace-Europe, a Luxembourg-based subsidiary.

The four-wheeled robot features a high-definition camera and will attempt to scoop up regolith, the moon's loose surface material.

These ambitious goals hinge on achieving a successful soft landing – a task fraught with challenges. Spacecraft must navigate treacherous boulders and craters and, in the absence of an atmosphere to support parachutes, rely entirely on thrusters for a controlled descent.

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The article discusses the concept of 'blood money' in Islamic law, explaining its use in various countries and its role in crime compensation.

Does 'blood money' have a legal standing?

What does 'blood money' mean? How does it figure in Islamic Sharia law? Do different Islamic nations have different rules with respect to determining the amount of money to be paid to the victim's family by the accused? What does 'plea bargaining' in India mean?

EXPLAINER

R. Sai Venkatesh

The story so far:

The death sentence awarded by a Yemen court to nurse Nimisha Priya from Kerala for murdering her business partner, and the subsequent debates and efforts surrounding her acquittal and repatriation, which involves monetary compensation paid to the victim's family, have brought the focus back on 'blood money' and its implications.

What is 'blood money'?

'Blood money', or 'diya', finds footing in the Islamic Sharia law, and is followed in countries that incorporate these laws in their legislation. Under the rule of 'diya', a select quantity of a valuable asset, primarily monetary, has to be paid by the perpetrator of the crime to the victim, or the victim's family if the latter has died. The custom is practised predominantly in cases involving unintentional murder and culpable homicide. It is also invoked in murder cases wherein the victim's kin chooses not to retaliate through 'qisas' (a way of retribution under the Sharia). The end-goal, as the law says, is not to put a price tag on human life, but to alleviate the plight and suffering of the affected family and their potential loss of income. However, it is to be noted that even if the concerned parties reconcile through 'blood money', the community and the state will retain the right to impose a deterrent punishment, including penalties.

In its contemporary applications, 'blood money' is upheld in several Islamic countries with factors such as gender, religion and nationality of the victim coming into play. Islamic scholar-researcher Mohammad Hashim Kamali outlines several cases in his book *Crime and Punishment in Islamic Law: A Fresh Interpretation*. In Saudi Arabia, for instance, the traffic regulations specifically mandate payment of 'blood money' to heirs of the victim who die in road accidents. In addition, the perpetrator shall be liable to a prison term. The statutory legislation and the Sharia work hand in hand in such cases. While the police determine the guilty parties, a Sharia court fixes the amount of 'blood money' to be paid. As for accidents in workplaces, the rates are fixed by a special committee. In 2022, talks had surfaced that Saudi Arabia was on the course to amend its 'blood money' laws, proposing equal monetary payments for men, women, Muslims and non-Muslims alike. However, efforts towards this are yet to come to fruition.

In Iran too, a country where the practice is rigorously upheld, 'blood money' varies with respect to religion and gender. A woman's compensation is fixed at half of that of a man's. In 2019, the country's Supreme Court upheld a law that sought equalisation of 'blood money'. However, the country is yet to see its full-fledged implementation. India's neighbour Pakistan, too, provides a place for 'diya' and 'qisas'. Through the Criminal Laws (Amendment) Ordinance, 1991, these provisions were brought into mainstream law. In Yemen, the country in question, the consensus for compensation can be arrived at by the parties, and there might be a judicial oversight over the fairness of the compensation.

What's India's stand on 'diya'?

Provisions for the grant or receiving of 'blood money' do not find a place in India's formal legal system. However, the system does provide a way for the accused to negotiate with the prosecution through 'plea bargaining'.

Though the concept cannot be directly equated with 'blood money', the scheme lays out a procedure whereby the defendant agrees to plead guilty for a particular offence perpetrated by the accused in return for a concession from the prosecutor. The concessions can be offered on a charge or a sentence. In the former, the defendant may plead guilty for one of the several charges or a less severe charge in return for dismissal of other charges, and in the latter, for a reduced sentence than what is prescribed for the concerned offence.

Introduced into legal parlance through the Criminal Law (Amendment) Act, 2005, which added Chapter XXI A to the Code of Criminal Procedure, 1973, plea bargaining comes with an array of limitations unlike 'blood money', which has a broader purview. For instance, plea bargaining can be taken up only for offences that are penalised with imprisonment of less than seven years. It cannot be invoked if the accused has been previously convicted for a similar offence. Besides, the provision is not available for crimes against women or children aged below 14; heinous crimes such as murder or rape; and offences involving socio-economic conditions, including civil rights. Moreover, the accused has to voluntarily come forward to plead guilty, and must not be coerced.

However, on the lines of 'blood money', plea bargaining may also allow for the victim to receive compensation under clause Section 265E. Besides, much like the efforts in Islamic nations towards making 'blood money' more inclusive and egalitarian, discussions have been under way to make plea bargaining more refined.

Though its use has been minimal in India, experts have pointed out that owing to judicial delays and prolonged trials, accused persons, even if innocent, may be pushed to a situation to plead guilty under the plea bargaining clause.

What are some historical practices which are similar to 'blood money'?

Striking similarities to 'diya' can be found in the historical records of several other cultures across the globe.

In the ancient legal system of Ireland, the Brehon law (seventh century AD) provided for the system of 'Éraic' (body price) and 'Log nEnech' (honour price). The law shunned the notion of capital punishment for crimes, and allowed resolution of matters through amicable payment. In Éraic, the amount was determined by the severity of the offence, while in Log nEnech, the price varied depending upon the victim's social status.

'Galanas' was an early Welsh law wherein the compensation was determined according to the status of the victim. Under the ruling, 'blood fine' was always to be paid, especially in cases of murder, barring where the killing was justified or excused owing to circumstances, points out author Thomas Peter Ellis in the book *Welsh Tribal Law and Customs in the Middle Ages*.

'Wergeld', a concept that is said to have been formalised in early medieval Germany, greatly resembles 'blood money'.

American legal professional Roscoe Pound's book, *The Ideal Element in Law* points out that, in fact, several medieval States had set their standards for an appropriate payment to the kin of victims in the event of homicide or grave crimes.

Have there been other Indians who were pardoned with 'blood money'?

While Nimisha Priya's case is in the spotlight now, there have been several other instances involving Indian nationals where 'blood money' had been invoked.

As recently as in 2019, the death sentence of Arjunan Athimuthu, hailing from Thanjavur, in Kuwait was commuted to life imprisonment after his family provided ₹30 lakh in 'blood money'. Abdul Rahim, who was sentenced to death in the murder of a Saudi boy in 2006, was pardoned by the court after a 'blood money' of ₹34 crore was paid. However, he is yet to be released from prison. Ten Indians in the UAE were "forgiven" by the victim's family in 2017 after a 'blood money' of 200,000 dirhams was paid. In another case, 17 Indians who were on death row in the UAE for the murder of a Pakistani national in 2009, were pardoned after a 'blood money' of nearly ₹4 crore in value equalling dirhams was paid. The Indian consulate had even hired a law firm in the UAE to argue the case.

As for Nimisha, with Iran assuring India of taking up the case, it remains to be seen whether her death sentence would be commuted.

Grave accidents: Prema Kumari, mother of Nimisha Priya who is on death row in Yemen for the alleged murder of a Yemeni national. THULASI KAKKAT

THE GIST

'Blood money', or 'diya', finds footing in the Islamic Sharia law. Under the rule of 'diya', a select quantity of a valuable asset, primarily monetary, has to be paid by the perpetrator of the crime to the victim, or the victim's family if the latter has died.

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- It also explores India's legal stance, historical parallels, and recent instances of its application.

What is 'Blood Money'?

- 'Blood money', also known as 'diya', is a concept under Islamic Sharia law.
- It involves paying a specified sum of money to the victim or their family in cases of unintentional murder or homicide.

- The goal is not to value human life but to alleviate the suffering of the victim's family and cover their potential loss of income.
- If the family of the victim forgives the perpetrator, they may choose to accept 'blood money' instead of retribution (qisas).
- Even if 'blood money' is accepted, the community and state may still impose punishments, including fines.

Contemporary Use of 'Blood Money'

- Several Islamic countries follow 'blood money' laws, with variations in how compensation is calculated.
- In Saudi Arabia, for example, 'blood money' is mandated in traffic accidents, and a prison term is also imposed on the perpetrator.
- 'Blood money' laws in Saudi Arabia, Iran, and Pakistan differ by gender, religion, and nationality.
- In Iran, a woman's compensation is half that of a man's, though there have been efforts to equalize it.
- Pakistan incorporates 'blood money' and retribution in its legal system.
- Yemen also allows the parties to reach a compensation agreement, with judicial oversight.

India's Stand on 'Blood Money'

- India does not have a formal legal provision for 'blood money'.
- However, India has a similar concept known as 'plea bargaining', introduced by the Criminal Law (Amendment) Act, 2005.
- Plea bargaining allows the accused to plead guilty in exchange for a reduced sentence or fewer charges.
- Unlike 'blood money', plea bargaining has limitations; it only applies to offenses punishable with less than seven years of imprisonment and cannot be used in heinous crimes like murder or rape.
- In plea bargaining, victims may receive compensation, similar to 'blood money', under Section 265E of the Criminal Procedure Code.

Historical Practices Similar to 'Blood Money'

- Similar practices to 'blood money' have existed in many cultures.
- In ancient Ireland, the Brehon law included 'Éraic' (body price) and 'Log nEnech' (honor price), which provided compensation based on the severity of the crime and the social status of the victim.

- Welsh laws also had a similar compensation system called 'Galanas', where the amount depended on the victim's social rank.
- The Germanic 'Wergeld' also involved compensating the family of the victim in cases of homicide or serious crimes.

Indian Cases Involving 'Blood Money'

- Several Indian nationals have been pardoned through 'blood money' in the past.
- In 2019, the death sentence of an Indian in Kuwait was commuted to life imprisonment after his family paid 'blood money'.
- Other Indian nationals in the UAE were pardoned after paying 'blood money' for serious crimes.
- In the current case, efforts are underway to see if a death sentence can be commuted through 'blood money'.

Conclusion

- 'Blood money' serves as a tool for reconciliation in certain legal systems, aiming to compensate victims' families.
- It remains a contentious issue, with debates on its fairness and implementation across different countries.

UPSC Mains Practice Question

Ques : Discuss the concept of 'blood money' under Islamic law and compare it with India's plea bargaining system. (150 Words /10 marks)

Page 13 : Prelims Fact

Argentina has seen significant inflation reduction under President Javier Milei's austerity measures, which include budget cuts and public sector layoffs, leading to economic challenges and protests.

Status of Argentine Economy:

- In 2024, Argentina's inflation rate dropped to 117.8%, a sharp decline from previous years, signaling a reduction in price increases.
- The government, under President Javier Milei, claims this drop in inflation reflects the success of its stabilization plan, which began with his tenure.
- Milei's austerity measures, which included a 52% devaluation of the peso and the firing of over 33,000 public sector employees, played a key role in reducing inflation.
- Despite these efforts, poverty is high, with 57.4% of people living below the poverty line.
- Instead these reforms plunged Argentina into a deep recession, pushing an additional five million people into poverty in 2024.
- Despite facing protests, Milei asserts that the economic pain will result in long-term economic stability and growth.

Argentine inflation drops

Long game: Javier Milei insists short-term pain will lead to long-term gains for the economy. REUTERS

Agence France-Presse
BUENOS AIRES

Javier Milei's government boasted Tuesday that it had "pulverized inflation" after statistics showing Argentine price increases falling to 117.8% in 2024, down nearly 94 points in the first full year since the budget-slashing president took office.

Inflation, the perennial bugbear of South America's second-biggest economy, stood at 2.7% in December, up slightly from 2.4% a month earlier. But it was the third straight month in which prices rose by less than 3%, the INDEC statistics institute said.

"In just 12 months we pulverized inflation," the Economy Ministry wrote on X, adding that "the data reflects the success of the stabilization plan" launched by Mr. Milei when he came to power wielding a chainsaw as a symbol of his plan to restore fiscal discipline and runaway prices.

Mr. Milei at the time declared that the fast-rising prices, which have haunted Argentinians for decades, would soon be "little more than a bad memory."

During Mr. Milei's first month in office, inflation hit a record 25.5% after he devalued the beleaguered peso by 52%. But by November 2024, it had fallen to its lowest level in over four years on the back of a drastic austerity program, which has included firing more than 33,000 public sector workers.

His measures, which plunged Argentina into a deep recession, were accused of tipping an additional five million people into poverty in the first half of 2024 and brought tens of thousands of people onto the streets in protests.

Mr. Milei has swatted away criticism, however, insisting that what he presents as short-term pain will lead to long-term gains for the economy.

In News : INS Nilgiri, INS Surat, and INS Vaghsheer Commissioned into Indian Navy

The Indian Navy has inducted three cutting-edge vessels — INS Nilgiri, a stealth frigate, INS Surat, a guided missile destroyer, and INS Vaghsheer, a Scorpene-class submarine , marking a significant leap in its operational and strategic capabilities.

Analysis of the news:

- **INS Nilgiri: Versatile Stealth Frigate**
  - INS Nilgiri, the lead ship of the Project 17A frigates, is designed for multi-mission operations in blue-water environments.
  - Equipped with supersonic missiles, advanced air defense systems, and rapid-fire weapons, it excels in anti-surface, anti-air, and anti-submarine warfare.
  - Built with an "integrated construction" approach, it reduces build time and enhances efficiency.

- The frigate represents a modern upgrade to the Shivalik-class vessels, with six more ships under Project 17A in various construction stages.

INS Surat: AI-Enabled Stealth Destroyer

- The fourth and final destroyer under Project 15B, INS Surat, is India's first AI-enabled warship.
- Designed for offensive operations, it features advanced sensors, surface-to-air missiles, and anti-ship weaponry.
- With a displacement of 7,400 tonnes and speeds exceeding 30 knots, it integrates seamlessly into network-centric warfare.
- This destroyer underscores India's focus on combining cutting-edge technology with indigenous design, ensuring high maneuverability and strike capability.

INS Vaghsheer: Silent and Lethal Submarine

- INS Vaghsheer, the final vessel of the Kalvari-class submarines under Project 75, is a diesel-electric "hunter-killer" submarine.
- Renowned for its stealth and versatility, it is equipped with wire-guided torpedoes, anti-ship missiles, and advanced sonar systems.
- The modular construction facilitates future upgrades, including Air Independent Propulsion (AIP) technology, enhancing underwater endurance.
- Vaghsheer is pivotal for missions like surveillance, intelligence gathering, and special operations.

Strategic Significance of the Additions

- The simultaneous commissioning of a frigate, destroyer, and submarine showcases India's naval prowess and its commitment to bolstering maritime security.
- These platforms enhance India's capability to deter regional threats, secure maritime trade routes, and maintain strategic influence in the Indian Ocean Region (IOR).
- Their indigenous origin aligns with India's Make in India initiative and reinforces global confidence in India's defense production capabilities.

The red flag as China's expansionist strategy rolls on

Rahul M. Lad

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In recent days, India has witnessed two significant incidents of Chinese aggression along the China-India border, highlighting vulnerabilities that not only threaten India's territorial integrity but also undermine its sovereignty. The Chinese government's announcement of the construction of a dam on the Yarlung Zangbo river (which is the Brahmaputra river), and the creation of two new counties in north-eastern Ladakh, have set alarm bells ringing.

India has strongly condemned these Chinese actions, asserting that they are illegal and a direct challenge to India's sovereignty. In response to China's ambitious hydropower project, India has expressed concern, noting that it is monitoring the situation and will take necessary measures to safeguard its national interests. These developments are particularly disturbing given the recent consensus on troop disengagement along the Line of Actual Control (LAC). These new moves further underscore the unpredictability of China's approach in the region.

The transboundary water issue

India is not alone in facing the brunt of China's expansionist policies. Other South Asian countries such as Nepal and Bhutan have been subjected in a similar manner to Chinese territorial encroachments. Disputes over land boundaries persist between China and several of its South Asian neighbours, and China's unilateral actions with respect to transboundary rivers, particularly the Brahmaputra and Indus river systems, have the potential to jeopardise water security in India, Nepal, Bangladesh, Bhutan, and Pakistan. Despite these challenges, each country has opted to engage with China on a bilateral basis.

The proposed Chinese dam, with an annual capacity to generate 300 billion kilowatt-hours of electricity a year, is located on the lower reaches of the Yarlung Zangbo near the China-India border. This massive infrastructure project presents significant challenges for downstream countries, particularly India and Bangladesh.

The construction of the dam is likely to reduce the amount of water and silt reaching downstream, which could have severe long-term consequences for agriculture, fisheries, and biodiversity in India and Bangladesh. Further, during the monsoon season or in times of geopolitical tensions, the uncontrolled release of water could result in devastating floods along the Indian border, which will be an issue of strategic vulnerability for India. In anticipation, India has accelerated plans to build its own hydropower projects and reservoirs, including an investment of $1 billion to expedite the construction of 12 hydropower stations in Arunachal Pradesh.

India, as the dominant regional power in South Asia, should take the lead in shaping a collective response to China's aggressive actions

Border disputes, cartographic aggression

China's recent actions, including the creation of the two new counties, are a part of its ongoing strategy of cartographic aggression aimed at asserting control over disputed territories. This kind of tactic is intended to gain strategic leverage over its regional adversaries.

China's territorial disputes with India are multifaceted, with the most recent aggression occurring along the western front, specifically in Ladakh. Additionally, China continues to lay claim to Arunachal Pradesh, a State that is an inalienable part of India. Beyond India, China also asserts overlapping claims on territories in countries such as Nepal and Bhutan.

China's tactics in asserting territorial claims– such as renaming locations within Indian-controlled territories, establishing settlements in disputed areas, and incorporating contested regions into official maps – are becoming increasingly visible. For instance, in 2023, the Chinese government standardised 11 locations in Arunachal Pradesh to assert its ownership, following similar actions in 2021 and 2017.

However, international law does not recognise territorial claims based solely on cartographic assertions. In various landmark cases, which include the ruling by the International Court of Justice (ICJ) on the Minquiers and Ecrehos dispute between the United Kingdom and France, maps were deemed insufficient evidence of sovereignty. The ICJ ruled that effective administrative control and sovereignty are crucial for determining ownership of contested territories. Therefore, China's use of cartographic aggression, while provocative, lacks legal validity under international law. Nevertheless, China's efforts to establish a physical presence in disputed territories, such as by building settlements, could complicate matters for India in the future.

The South Asian response

While China has sought economic engagement with all South Asian nations, its territorial and water-related disputes with these countries continue to strain regional relations. Unlike the Southeast Asian nations, which have employed collective responsive measures through multilateral organisations such as the Mekong River Commission (MRC) and the Association of Southeast Asian Nations (ASEAN), South Asian countries, including India, have chosen to address their concerns with China on a bilateral basis. This approach has largely been shaped by the power asymmetry between China and its smaller neighbours.

India, as the dominant regional power in South Asia, should take the lead in fostering a collective response to China's actions. A unified approach, including regional forums, multilateral institutions, or enhanced diplomatic coordination would strengthen South Asia's position in addressing China's increasing influence and territorial ambitions. A comprehensive strategy involving diplomatic engagement and regional cooperation is crucial for India's sovereignty and regional security in the face of China's growing assertiveness.

GS Paper 02 : International Relations – Bilateral Relations

PYQ: (UPSC CSE (M) GS-2 2017) : 'China is using its economic relations and positive trade surplus as tools to develop potential military power status in Asia', In the light of this statement, discuss its impact on India as her neighbor. **(150 words/10m)**

UPSC Mains Practice Question: How do China's territorial and hydropower initiatives along the India-China border impact India's sovereignty and water security? Propose strategic measures to address these challenges effectively.**(250 Words /15 marks)**

Context :

- India faces Chinese aggression through territorial claims and hydropower projects, threatening sovereignty, regional stability, and water security.

Chinese Aggression Along the India-China Border

- Recently, India faced two major incidents of Chinese aggression along its border: the announcement of a dam on the Yarlung Zangbo river (Brahmaputra) and the creation of two new counties in northeastern Ladakh.
- India condemned these actions as illegal and a direct threat to its sovereignty.
- India expressed concerns over China's hydropower project and is monitoring the situation to safeguard its national interests.
- These developments follow troop disengagement agreements along the Line of Actual Control (LAC), highlighting China's unpredictable approach.

Transboundary Water Issues

- China's actions affect not only India but also South Asian countries like Nepal and Bhutan, which face territorial encroachments.
- China's unilateral management of transboundary rivers like the Brahmaputra and Indus threatens water security in India, Nepal, Bangladesh, Bhutan, and Pakistan.
- The proposed Chinese dam can generate 300 billion kilowatt-hours annually but poses risks for downstream countries.
- The dam may reduce water and silt flow, impacting agriculture, fisheries, and biodiversity in India and Bangladesh.

- The uncontrolled release of water during monsoons or geopolitical tensions could cause devastating floods in India.
- India is investing $1 billion to fast-track 12 hydropower projects in Arunachal Pradesh to counter this challenge.

Border Disputes and Cartographic Aggression

- China has intensified its cartographic aggression by renaming locations, creating new counties, and incorporating disputed regions into its maps.
- In Ladakh, China's actions aim to assert control over contested territories, while it also lays claim to Arunachal Pradesh, which is an integral part of India.
- Beyond India, China has overlapping territorial claims with Nepal and Bhutan.
- While China's cartographic assertions lack legal validity under international law, its establishment of settlements in disputed areas complicates sovereignty claims.

The South Asian Response

- South Asian nations, including India, address disputes with China bilaterally, unlike Southeast Asian nations that use multilateral mechanisms like the Mekong River Commission and ASEAN.
- India, as a regional leader, needs to foster a collective South Asian response to counter China's territorial and water-related actions.
- Regional forums, multilateral institutions, and diplomatic coordination can strengthen South Asia's position.
- A unified approach is essential to safeguard India's sovereignty and regional security against China's growing assertiveness.

Conclusion

- China's actions highlight its expansionist policies, threatening India's sovereignty and regional stability.
- A unified South Asian response and enhanced diplomatic efforts are essential to counter China's growing assertiveness and ensure security.