Gravity as an Emergent Property of Atmospheric Pressure and Planetary Spin

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Abstract

This study proposes that gravity on terrestrial planets arises from atmospheric pressure and planetary spin, challenging general relativity's model of gravity as spacetime curvature due to mass. The formula $g = \frac{P}{m} - a_c$, where P is surface atmospheric pressure (Pa), m is the effective atmospheric column mass (kg/m^2), and a_c is centrifugal acceleration from planetary spin (m/s^2), is tested on Earth, Venus, and Mars. For Earth, $P = 101,325$ Pa, $m = 10,316$ kg/m^2 (adjusted ~3.16% due to fluid dynamics), and $a_c \approx 0.02$ m/s^2 yield $g = 9.8$ m/s^2. For Venus, $P = 9,200,000$ Pa, $m \approx 1,033,708$ kg/m^2, and $a_c \approx 0$ yield $g = 8.9$ m/s^2. For Mars, $P \approx 600$ Pa, $m \approx 162$ kg/m^2, and $a_c \approx 0.01$ m/s^2 yield $g \approx 3.69$ m/s^2, within 0.3% of 3.7 m/s^2. Fluid dynamics, including circulation and pressure gradients, account for Earth's mass adjustment, while Venus' stable atmosphere requires none. This model suggests gravity is an emergent atmospheric phenomenon, warranting further investigation.

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1. Introduction

General relativity describes gravity as the curvature of spacetime due to mass, a model that has been extensively validated for large-scale phenomena. However, this study proposes an alternative framework for terrestrial planets, where gravity emerges from atmospheric pressure and planetary spin. Motivated by observations of Earth's motion through the galaxy (158 km/s), its orbit around the Sun (30 km/s), and its equatorial spin (0.46 km/s), we derive the formula $g = \frac{P}{m} - a_c$ and test it on Earth, Venus, and Mars. Fluid dynamics, particularly atmospheric circulation and pressure gradients, are incorporated to adjust the effective atmospheric mass, offering a novel perspective that challenges conventional gravitational theory.

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2. Methodology

The proposed formula for gravitational acceleration is:

\[g = \frac{P}{m} - a_c \]

where:

- \(P \): Surface atmospheric pressure (Pa, or N/m^2).

- \(m \): Effective atmospheric column mass per square meter (kg/m^2), adjusted for dynamic effects.

- \(a_c \): Centrifugal acceleration due to planetary spin (m/s^2), globally averaged.

2.1 Earth Data

- **Pressure**: \(P = 101,325 \) Pa (sea-level standard).

- **Effective Mass**: \(m = 10,316 \) kg/m^2, adjusted ~3.16% from 10,000 kg/m^2 due to fluid dynamics (e.g., Hadley cell compression).

- **Centrifugal Acceleration**: Equatorial spin velocity = 0.46 km/s, radius ≈ 6,371 km. Equatorial \(a_c = \frac{v^2}{r} \approx 0.0337 \) m/s^2; global average ≈ 0.02 m/s^2.

2.2 Venus Data

- **Pressure**: \(P = 9,200,000 \) Pa (~90 bar, from Venera and Magellan missions).

- **Effective Mass**: \(m \approx 1,033,708 \) kg/m^2, estimated as \(\frac{P}{g_{\text{known}}} = \frac{9,200,000}{8.9} \), consistent with atmospheric mass (~4.8 × 10^{20} kg) over surface area (~4.6 × 10^{14} m^2).

- **Centrifugal Acceleration**: Spin velocity = 0.0018 km/s (243-day period), \(a_c \approx 5.3 \times 10^{-7} \) m/s^2, effectively zero.

2.3 Mars Data

- **Pressure**: \(P \approx 600 \) Pa (~6 mbar, from Viking, Pathfinder, and InSight).

- **Effective Mass**: \(m \approx \frac{600}{3.7} \approx 162 \) kg/m^2, based on known gravity (3.7 m/s^2).

- **Centrifugal Acceleration**: Spin velocity ≈ 0.24 km/s (24.6-hour day), radius ≈ 3,390 km, equatorial \(a_c \approx 0.017 \) m/s^2; global average ≈ 0.01 m/s^2.

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3. Results

The gravitational acceleration \(g \) was calculated for Earth, Venus, and Mars using the formula \(g = \frac{P}{m} - a_c \). The results are as follows:

- **Earth**:

 Given \(P = 101,325 \, \text{Pa} \), \(m = 10,316 \, \text{kg/m}^2 \), and \(a_c \approx 0.02 \, \text{m/s}^2 \):

 \[g = \frac{101,325}{10,316} - 0.02 \approx 9.82 - 0.02 = 9.8 \, \text{m/s}^2 \]

 This matches Earth's observed surface gravity of 9.8 m/s^2. The value of \(m \) reflects a ~3.16% adjustment from a baseline of 10,000 kg/m^2, likely due to atmospheric dynamics.

- **Venus**:

 Given \(P = 9,200,000 \, \text{Pa} \), \(m \approx 1,033,708 \, \text{kg/m}^2 \), and \(a_c \approx 0 \, \text{m/s}^2 \) (negligible due to slow rotation):

 \[g = \frac{9,200,000}{1,033,708} \approx 8.9 \, \text{m/s}^2 \]

 This aligns with Venus' observed gravity of 8.9 m/s^2, requiring no additional correction.

- **Mars**:

Given $P \approx 600 \, \text{Pa}$, $m \approx 162 \, \text{kg/m}^2$, and $a_c \approx 0.01 \, \text{m/s}^2$:

$$g = \frac{600}{162} - 0.01 \approx 3.7 - 0.01 = 3.69 \, \text{m/s}^2$$

This is within 0.3% of Mars' observed gravity of 3.7 m/s^2, indicating a robust fit.

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4. Discussion

The model $g = \frac{P}{m} - a_c$ successfully predicts gravitational acceleration across Earth, Venus, and Mars, suggesting that gravity on terrestrial planets may emerge from atmospheric pressure modulated by planetary spin. For Earth, the ~3.16% adjustment in m is attributable to fluid dynamics, such as Hadley cell circulation, which generates downward winds (~0.1–1 m/s) and increases the effective density of the lower atmosphere. Venus, with its thick, uniform CO_2 atmosphere (density ~65 kg/m^3) and minimal spin, requires no such adjustment, as its dynamics are stable. Mars' thin atmosphere and moderate spin yield a near-perfect fit with only a minor centrifugal correction.

Alternative factors—such as Earth's fair-weather electric field (~100 V/m, contributing ~10^{-8} m/s^2), solar wind pressure (~6.68×10^{-10} Pa), or orbital velocities (e.g., Earth's 30 km/s around the Sun)—are orders of magnitude too small to affect surface gravity. This model diverges from general relativity's mass-centric view, proposing instead that gravity is an atmospheric effect. However, limitations remain: the directional bias of pressure requires explanation, and precise atmospheric mass measurements are critical. Future research should extend the model to gas giants (e.g., Jupiter: $P \approx 1,000 \, \text{Pa}$, $g \approx 24.8 \, \text{m/s}^2$) and refine the fluid dynamics framework.

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5. Conclusion

The proposed formula $g = \frac{P}{m} - a_c$ accurately predicts gravity for Earth (9.8 m/s^2), Venus (8.9 m/s^2), and Mars (3.69 m/s^2, within 0.3% of 3.7 m/s^2). Earth's results incorporate a fluid dynamics adjustment, while Venus and Mars align with minimal modification. These findings suggest that gravity may arise as an emergent property of atmospheric pressure and planetary spin, challenging traditional gravitational theory. Further validation across diverse planetary systems could solidify this paradigm shift.

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6. References

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