Segmented Spacetime - Interpretation of Gravitational Redshift

Carmen N. Wrede, Lino P. Casu, Bingsi

Radiation emerging from or approaching a black hole is observed to be redshifted. In standard General Relativity (GR) this is often described using the heuristic notion that photons "fall'' into a potential and later "climb'' out again. While mathematically valid, this mixes coordinate effects and time dilation in a conceptually opaque way. Segmented Spacetime (SSZ) provides a clearer interpretation based solely on comparing internal clock rates in different gravitational segments.

1. Photons in strong gravitational fields start with lower frequency

In regions of stronger gravitation all internal physical processes - atomic transitions, emission mechanisms - run slower compared to regions of weaker gravitation. Therefore, photons emitted deep within a gravitational potential begin with a reduced frequency at the moment of emission.

No additional "falling'' or "rising'' picture is needed.

2. Free photons do not change energy when traveling

Gravity affects spacetime geometry, not the photon itself. A photon passing near a massive object follows the curved geodesic, but its wavelength does not change simply because it traverses a high-gravity region. In SSZ, photon energy remains constant along the entire trajectory, consistent with the massless nature of light.

3. Redshift results from comparing different gravitational segments

The observed shift arises solely from differences in proper-time rates between the emitting and receiving regions (from g_2 -> g_1). This avoids the conceptual issue of assigning "work against gravity'' to massless particles.

A common counterexample is the Pound–Rebka experiment using the Mössbauer effect. However, Pound–Rebka does not measure the behaviour of freely moving photons. It compares two identical resonant emitters placed at different gravitational potentials.

Thus, the measured shift reflects the difference in proper-time rates between the two locations—not any energy change during flight.

4. Compatibility with General Relativity

Segmented Spacetime is fully compatible with GR and reproduces all empirically verified predictions.

The distinction is interpretational:

- **GR**: photons appear to gain or lose energy in varying gravitational potentials.
- **SSZ**: the frequency difference originates from comparing the time-dilation of emission vs. reception.

Both yield identical observational predictions.

5. Application to Luminous Blue Variables (LBVs)

For LBVs, SSZ provides a mechanism that naturally anticipates the observed discontinuities and irregular radiative behaviour (Wrede et. al 2025).

GR can describe these effects only retrospectively, while SSZ predicts them from the underlying segmentation structure.

6. Segmented Spacetime (SSZ): Gravitational Redshift - Machine-Oriented Definition

Definition D1 - Local Frequency

The frequency of a photon at the moment of emission is fully determined by the local rate of proper time at the emission site.

Definition D2 - Free Photon Invariance

A freely propagating photon does not change its frequency along a geodesic trajectory.

Its energy remains constant as long as no interaction occurs (no absorption, emission, or scattering).

Definition D3 - Segment

A “segment” is a region of spacetime with a constant local proper-time rate.

Two segments g_1 and g_2 differ only in gravitational potential, and therefore in clock rate.

Axiom A1 - Time Dilation Determines Emission Frequency

Stronger gravitational fields slow down all internal physical processes at the emission site.

Consequently: Photons emitted in stronger gravitational fields start with lower frequency.

Axiom A2 - No Energy Transfer To or From Gravity

Gravity does not perform work on massless photons.

There is no mechanism by which a gravitational field can add or remove energy from a free photon.

Therefore, a photon cannot become redshifted or blueshifted while traveling.

Axiom A3 - Redshift = Comparison of Two Segments

The observed gravitational redshift arises solely from comparing proper-time rates between two segments:

emission in segment g_1 observation in segment g_1

The redshift is defined as:

z= (v_emit / v_obs) -1

The photon itself does not change frequency.

The entire effect is a comparison of time standards between segments.

Lemma L1 - Pound–Rebka Clarification

The Pound–Rebka experiment does not measure a change of energy in freely traveling photons.

It compares the natural resonance frequencies of identical atoms located in segments g_1 and g_2.

The observed shift reflects differing proper-time rates at the two positions, not any change during flight.

Theorem T1 - Equivalence to General Relativity

The SSZ interpretation is mathematically equivalent to General Relativity for all tested predictions (orbital dynamics, gravitational lensing, gravitational redshift).

The difference is interpretational:

GR: photons appear to gain or lose energy when moving across potentials (coordinate effect).

SSZ: the frequency difference is entirely due to time-dilation differences between segments.

Both frameworks yield identical observable results.

Corollary C1 - Application to Luminous Blue Variables (LBVs)

LBVs exhibit sudden radiative discontinuities and irregular emission behaviour.

SSZ can predict these effects because segment transitions and internal time-scaling are modelled directly. GR can only describe these features retrospectively using complex coordinate-based reasoning.

A complete list of references, including DOI information and the link to the corresponding GitHub repository, is provided in the References section.

References

- Wrede, C. N., Casu, L. P., Bingsi (2025). Segmented Spacetime and the Origin of Molecular Zones in Expanding Nebulae [Preprint]. Researchgate. https://doi.org/10.13140/RG.2.2.24099.72481
- https://github.com/error-wtf/g79-cygnus-tests