A Classical Velocity-Dependent Propagation Model for Electromagnetic Radiation: Application to Supernova Light Curves and Spectral Evolution

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Abstract

*This paper introduces the **Classical Velocity-Dependent Propagation (CVDP) model**, which proposes that the initial propagation velocity of an electromagnetic wave depends on the radial velocity of the emitting particle at the moment of emission. Within this framework, radiation emitted simultaneously by particles moving with different radial velocities reaches a distant observer at different times, producing a propagation-induced temporal stretching of transient astronomical events.*

A quantitative expression for the observed duration is derived and shown to predict temporal stretching that increases with both source distance and emitter velocity dispersion. Direct application of the model, however, predicts durations considerably longer than those observed for supernova light curves.

To account for this difference, the paper proposes coherent electromagnetic propagation as a mechanism that gradually reduces the effective propagation-velocity dispersion during propagation. This process is characterized by a coherence parameter k, whose approximate values are estimated from representative supernova observations.

The model also predicts a characteristic temporal evolution of observed spectra, in which initially blue shifted radiation is followed by nearly unshifted radiation and finally by progressively redshifted radiation. Possible observational tests capable of distinguishing the proposed propagation model from the conventional interpretation are discussed.

List of symbols

Symbol	Meaning
T	intrinsic explosion duration
t_p	observed duration
d	source distance
Δv	initial radial velocity dispersion
Δc_{eff}	effective propagation-velocity dispersion
k	coherence parameter

1. Introduction

The propagation of electromagnetic radiation from distant astronomical objects plays a central role in modern astrophysics. Observations of supernovae, gamma-ray bursts, fast radio bursts, and other transient phenomena provide valuable information about the physical processes occurring in extreme astrophysical environments. Their interpretation depends critically on the adopted model of electromagnetic-wave propagation.

Under this assumption, the observed duration of a transient event is determined primarily by the physical evolution of the source, geometrical light-travel effects, and radiative transfer within the expanding material. The propagation of light itself does not contribute to a significant temporal broadening of the observed signal.

The present paper introduces the Classical Velocity-Dependent Propagation (CVDP) model. The model assumes that, immediately after emission, the propagation velocity of an electromagnetic wave depends on the velocity of the emitting particle. Radiation emitted by particles moving toward the observer therefore propagates faster than radiation emitted by particles moving away from the observer. As a consequence, radiation emitted during a short explosive event may arrive over an extended period of time.

If this mechanism exists, the observed duration of a transient astronomical event depends not only on the intrinsic duration of the explosion but also on the distance to the source and on the velocity distribution of the emitting particles.

Direct application of this assumption predicts temporal stretching that is considerably larger than the durations observed for nearby and distant supernovae. This apparent discrepancy motivates the introduction of a second physical process proposed in this paper. During propagation, electromagnetic waves having nearly identical wavelength, phase, and propagation direction may gradually form coherent propagating structures. Such coherent propagation reduces the effective dispersion of propagation velocities while preserving the overall temporal ordering of the arriving radiation.

The combination of these two mechanisms—initial velocity-dependent propagation and subsequent coherent equalization—leads to a simple mathematical description of the observed duration of transient events. The model predicts that the observed duration increases with distance, while the effective velocity dispersion becomes substantially smaller than the initial velocity dispersion of the emitting particles.

An additional consequence of the model concerns the temporal evolution of observed spectra. Radiation emitted by particles approaching the observer is expected to arrive first, producing initially blue shifted spectra. Radiation emitted by particles moving approximately perpendicular to the line of sight follows, whereas radiation emitted by receding particles arrives last, producing progressively redshifted spectra. This behaviour differs qualitatively from the conventional interpretation of spectral evolution in expanding supernova ejecta.

The primary objective of this paper is not to provide a complete physical theory of coherent electromagnetic propagation, but to formulate the proposed propagation model in a quantitative form, derive its principal equations, apply it to observed supernova light curves, and identify observational tests capable of distinguishing its predictions from those of the conventional interpretation. [1], [2], [3], [6]

2. Fundamental Principles of the CVDP Model

The Classical Velocity-Dependent Propagation (CVDP) model is based on a small number of fundamental assumptions concerning the propagation of electromagnetic radiation immediately after its emission.

The first assumption is that the propagation velocity of an electromagnetic wave is initially determined by the velocity of the emitting particle at the moment of emission. Consequently, electromagnetic waves emitted by particles moving with different velocities do not necessarily propagate with identical velocities.

For an observer located along the direction of expansion, radiation emitted by particles moving toward the observer propagates faster than radiation emitted by particles moving away from the observer. Radiation emitted by particles moving perpendicular to the line of sight propagates with an intermediate velocity.

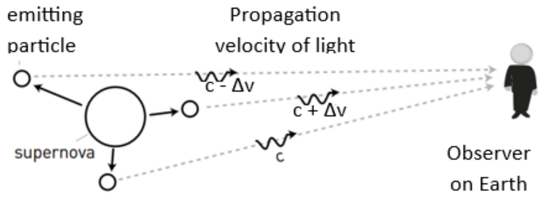

***Figure 1**: According to the CVDP model, the propagation velocity of light depends on the velocity component of the emitting particle along the observer's line of sight.*

Fundamental Postulate of the CVDP Model

Immediately after emission, the propagation velocity of an electromagnetic wave depends on the velocity of the emitting particle projected onto the observer's line of sight.

Accordingly, the propagation velocities may be expressed as c+ Δv, c, c- Δv, where c denotes the nominal speed of light and Δv represents the component of the emitter velocity projected onto the line connecting the source and the observer.

These assumptions imply that radiation emitted simultaneously by different parts of an expanding source does not arrive simultaneously at the observer. Instead, the observed signal becomes temporally ordered according to the propagation velocities of the emitted electromagnetic waves.

The CVDP model therefore predicts that the observed duration of an explosive astronomical event depends on three quantities:

- the intrinsic duration of the event,
- the distance between the source and the observer,
- the distribution of emitter velocities.

These fundamental principles form the basis of the mathematical development presented in the following sections. The first consequence of the model is the temporal ordering of radiation emitted by an expanding source, which is derived in the next chapter.

The CVDP model therefore introduces a one-to-one relationship between the velocity of the emitting particle and the initial propagation velocity of the emitted electromagnetic wave. All subsequent mathematical developments presented in this paper follow directly from this fundamental principle. [3]

3. Time Evolution of Radiation from an Expanding Source

3.1 General Description

Consider an explosive astronomical event occurring at a distance d from the observer. The explosion begins at time t=0 and lasts for an intrinsic time interval T.

According to the CVDP model, electromagnetic waves emitted by particles moving with different radial velocities propagate toward the observer with different propagation velocities. Consequently, radiation emitted simultaneously does not necessarily arrive simultaneously.

The objective of this chapter is to derive the resulting duration of the observed event.

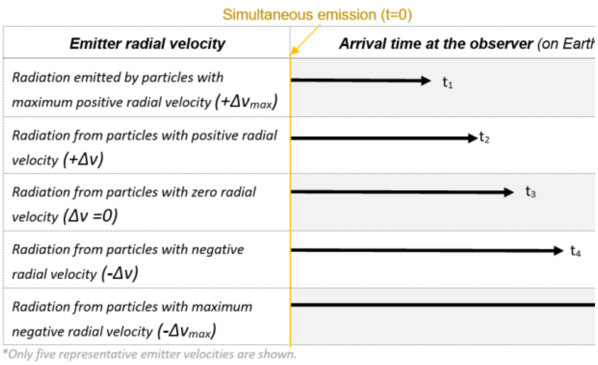

***Figure 2**. Temporal ordering of radiation predicted by the Classical Velocity-Dependent Propagation (CVDP) model. Radiation emitted simultaneously by particles with different radial velocities reaches the observer at different times because its initial propagation velocity depends on the emitter's radial velocity.*

3.2 Arrival Time of the Earliest Radiation

The first radiation reaching the observer originates from particles moving toward the observer. These particles possess the largest propagation velocity predicted by the CVDP model. According to the CVDP model, its initial propagation velocity is

$$c + \Delta v.$$

Therefore,

$$t_1 = \frac{d}{c + \Delta v}. \qquad (1)$$

3.3 Arrival Time of the Latest Radiation

The last arriving radiation originates from particles moving away from the observer. According to the CVDP model, its initial propagation velocity is

$$c - \Delta v.$$

Since this radiation is emitted at the end of the explosion,

$$t_2 = T + \frac{d}{c - \Delta v}. \qquad (2)$$

3.4 Observed Duration

The observed duration of a transient event increases with source distance because electromagnetic waves emitted by particles moving with different velocities propagate toward the observer with different propagation velocities. The observed duration is defined as the difference between the arrival times of the latest and earliest radiation

$$t_p = t_2 - t_1.$$

Hence,

$$\boxed{t_p = T + \frac{d}{c - \Delta v} - \frac{d}{c + \Delta v}} \qquad (3)$$

Equation (3) predicts that the observed duration increases with source distance and with the radial velocity dispersion of the emitting particles.

3.5 First-Order Approximation

Because of

$$\Delta v \ll c,$$

the denominator can be expanded to first order in

$$\frac{\Delta v}{c},$$

which gives

$$t_p \approx T + \frac{2d\Delta v}{c^2} \quad \textbf{(4)}$$

3.6 Physical Interpretation

Equation (4) represents the first quantitative prediction of the CVDP model. The first term represents the intrinsic duration of the explosion.

The second term represents the temporal stretching caused by the distribution of propagation velocities.

The stretching increases linearly with

- source distance,
- emitter velocity dispersion.

Consequently, distant transient events are expected to appear longer than identical nearby events.

The CVDP model therefore predicts that two identical explosions occurring at different distances will generally be observed with different durations.

3.7 Special Cases

Condition	Prediction
Δv = 0	$t_p = T$
Δv > 0	$t_p > T$

However, direct application of Equation (4) to observed supernovae predicts durations that are considerably longer than those actually observed. This apparent discrepancy motivates the introduction of an additional physical mechanism, discussed in the following chapter.

4. Predicted Duration of Transient Astronomical Events

4.1 Equation (4), hereafter referred to as the CVDP duration equation, will be used throughout the remainder of this paper.

$$t_p \approx T + \frac{2d\Delta v}{c^2}$$

Equation predicts that the observed duration of a transient astronomical event depends not only on its intrinsic duration but also on the distance between the source and the observer and on the velocity dispersion of the emitting particles.

Unlike conventional propagation models, the CVDP model predicts that the propagation process itself contributes to the observed temporal evolution of the event.

Consequently, two physically identical transient events occurring at different distances are generally expected to exhibit different observed durations.

4.2 Dependence on Distance

According to Equation (4), temporal stretching increases linearly with distance.

For nearby sources, the additional propagation time is expected to be very small.

For sufficiently distant sources, however, the propagation contribution may become comparable to or even exceed the intrinsic duration of the event.

The CVDP model therefore predicts that temporal stretching should become progressively more important for increasingly distant transient phenomena.

4.3 Dependence on Velocity Dispersion

Equation (4) also predicts that temporal stretching is directly proportional to the radial velocity dispersion of the emitting particles.

Transient events involving rapidly expanding ejecta are therefore expected to exhibit larger temporal stretching than events with smaller expansion velocities.

The predicted duration thus depends on two independent parameters:

- source distance,
- emitter velocity dispersion.

4.4 Physical Meaning

Equation (4) does not predict that the explosion itself lasts longer.

Instead, it predicts that radiation emitted during the explosion arrives at the observer over an extended time interval because different electromagnetic waves propagate with different initial velocities.

The temporal stretching therefore results from the propagation process rather than from the physical evolution of the source.

This distinction is fundamental for the CVDP model.

4.5 Emerging Difficulty

Direct application of Equation (4) to distant transient astronomical events leads to an important consequence. **The CVDP duration equation**, forms the basis for all subsequent developments presented in this paper.

For sufficiently large distances and realistic velocity dispersions, the predicted temporal stretching becomes considerably larger than the durations observed for nearby and distant supernovae.

The apparent discrepancy does not arise from the mathematical derivation, which follows directly from the fundamental postulate introduced in Chapter 2, but from the assumption that the initial propagation-velocity dispersion remains unchanged throughout propagation.

This observation suggests that an additional physical mechanism may act during propagation to reduce the effective dispersion of propagation velocities.

The following chapter investigates one possible mechanism capable of producing this effect.

5. Coherent Electromagnetic Propagation

5.1 Motivation

Direct application of the CVDP duration equation predicts temporal stretching that increases linearly with distance.

For distant astronomical events, however, the predicted duration becomes considerably longer than the observed duration of supernova light curves.

This suggests that the initial propagation-velocity dispersion may gradually decrease during propagation.

The present chapter proposes one possible physical mechanism capable of producing such a reduction.

5.2 Independent Electromagnetic Waves

Immediately after emission, electromagnetic waves originate independently from individual emitting particles.

Their initial propagation velocities reflect the radial velocities of the corresponding emitters.

Consequently, immediately after emission, the propagation-velocity distribution is expected to be relatively broad.

5.3 Formation of Coherent Structures

As electromagnetic waves propagate through space, waves having nearly identical wavelength, phase, propagation direction, and propagation velocity may gradually form coherent propagating structures.

Within such structures, the propagation velocities become partially equalized.

Consequently, the effective propagation-velocity dispersion becomes smaller than the initial dispersion present immediately after emission.

5.4 Effective Propagation Velocity Dispersion

The effective propagation-velocity dispersion is expressed as:

$$\Delta c_{eff} = k.\Delta v, \quad (5)$$

where

$$0<k<1.$$

The parameter k characterizes the efficiency of coherent equalization.

It is not assumed to be a universal constant.

Its value may depend on physical conditions during propagation.

5.5 Physical Interpretation of k

Coherence parameter k	Effective propagation-velocity dispersion	Expected temporal stretching	Physical interpretation
$k=1$	$\Delta c_{\text{eff}} = \Delta v$	Maximum	No coherent equalization. The initial propagation-velocity dispersion is fully preserved.
$0<k<1$	$\Delta c_{\text{eff}} = k\Delta v$	Partial	Partial coherent equalization gradually reduces the initial propagation-velocity dispersion.
$k \to 0$	$\Delta c_{\text{eff}} \to 0$	Negligible	Nearly complete coherent equalization. Propagation velocities become almost identical.

Table 1. Physical Interpretation of the Coherence Parameter k

5.6 Consequences

The effective propagation-velocity dispersion becomes

$$\Delta c_{\text{eff}} = k\Delta v,$$

therefore, the CVDP duration equation becomes

$$\boxed{t_p = T + \frac{2dk\Delta v}{c^2}} \quad (6)$$

The complete CVDP model that predicts the observed duration

Equation represents the effective observed duration predicted by the complete CVDP model.

This equation combines the initial velocity-dependent propagation with the proposed coherent equalization mechanism. [4], [5]

6. Application to Supernovae

6.1 Why Supernovae?

Supernovae represent one of the most suitable classes of astronomical objects for testing the CVDP model.

They possess several characteristics that make them particularly appropriate for investigating propagation-dependent temporal evolution.

First, supernova explosions produce rapidly expanding ejecta with radial velocities reaching several hundred to several thousand kilometres per second.

Second, supernovae are observed over a wide range of distances, from nearby galaxies to cosmological scales.

Third, their optical light curves and spectral evolution have been extensively documented, providing abundant observational material for comparison with theoretical predictions.

These properties make supernovae an appropriate first application of the CVDP model.

6.2 Expected Behaviour

According to the CVDP model, radiation emitted by particles moving toward the observer reaches the observer first, whereas radiation emitted by particles moving away arrives last.

Consequently, the observed duration of the event depends not only on the intrinsic duration of the explosion but also on the effective propagation-velocity dispersion.

If coherent equalization occurs during propagation, the observed duration is determined by Equation (6). Thus, the CVDP model predicts that both the temporal evolution and the spectral evolution of supernovae are influenced by propagation effects.

6.3 Comparison with Observations

Observed optical light curves of well-studied supernovae typically extend over several weeks or several months.

These durations are substantially shorter than those predicted by the original CVDP duration equation without coherent equalization, yet considerably longer than the intrinsic duration of the initial explosion.

Within the framework proposed in this paper, this behaviour is interpreted as evidence that the initial propagation-velocity dispersion has been significantly reduced during propagation.

6.4 Selected Supernovae

Selected supernovae and adopted observational parameters

Supernova	Host galaxy	Distance	Adopted characteristic ejecta velocity	Adopted optical duration t_p
SN 1054	Milky Way	6,500 ly	1,375 km/s	642 days
SN 1006	Milky Way	7,080 ly	5,000 km/s	≥ 2.5 years
SN 1987A	Large Magellanic Cloud	167,600 ly	3,000 km/s	120 days
SN 1993J	M81	12.9 million ly	10,000 km/s	120 days
SN 2011fe	M101	23.6 million ly	10,000 km/s	112 days

***Table 2**. Selected supernovae and the observational parameters adopted for the exploratory CVDP analysis. The listed velocities and optical durations are representative values rather than uniquely defined physical quantities. For the historical supernovae SN 1054 and SN 1006, the reported visibility intervals are used as approximate substitutes for modern photometric light-curve durations.*

6.5 Transition to the Next Chapter

The observed durations of the selected supernovae may be used to estimate the effective coherence parameter k introduced in Chapter 5.

The following chapter applies the complete CVDP duration equation to representative supernova observations and derives approximate values of this parameter.

The present comparison concerns only the observed duration of supernova light curves. Spectral evolution predicted by the CVDP model is considered separately in Chapter 8. [6]–[12]

7. Estimation of the Coherence Parameter

7.1 Method

The coherence parameter k cannot presently be derived from first principles within the CVDP model.

Its value can, however, be estimated by comparing the complete CVDP duration equation with observed durations of transient astronomical events.

For each selected supernova, the observed optical duration, the estimated distance, and the characteristic ejecta velocity are combined to obtain an approximate value of k.

7.2 Complete Duration Equation

$$t_p = T + \frac{2dk\Delta v}{c^2}$$

and rearrangement

$$k = \frac{(t_p - T)c^2}{2d\Delta v}. \quad \textbf{(7)}$$

7.3 Selected Supernovae

Supernova	Distance	Adopted expansion velocity Δv	Adopted optical duration t_p	Estimated k
SN 1054	6,500 ly	1,375 km/s	642 days	2.95×10^{-2}
SN 1006	7,080 ly	5,000 km/s	2.5 years	1.06×10^{-2}
SN 1987A	167,600 ly	3,000 km/s	120 days	9.8×10^{-5}
SN 1993J	12.9 million ly	10,000 km/s	120 days	3.8×10^{-7}
SN 2011fe	23.6 million ly	10,000 km/s	112 days	1.95×10^{-7}

Table 3. *Order-of-magnitude estimates of the coherence parameter k. The intrinsic emission duration T is neglected relative to the adopted optical duration t_p. Distances, characteristic expansion velocities, and optical durations are approximate and are used only for an exploratory comparison.*

Although the estimated values span several orders of magnitude, they all satisfy k≪1, indicating that the effective propagation-velocity dispersion is much smaller than the initial velocity dispersion assumed immediately after emission.

7.4 Interpretation

Although the estimated values are only approximate, they consistently indicate that the effective propagation-velocity dispersion is substantially smaller than the initial velocity dispersion of the ejecta.

Within the CVDP framework, this behaviour is interpreted as evidence for strong coherent equalization during propagation.

7.5 Limitations

The current estimates of the factor k shown in Figure 3 are intended only as order of magnitude estimates.

More accurate determination of the coherence parameter would require detailed modelling of individual supernova light curves, expansion velocities, and intrinsic explosion durations. [6], [9], [10]

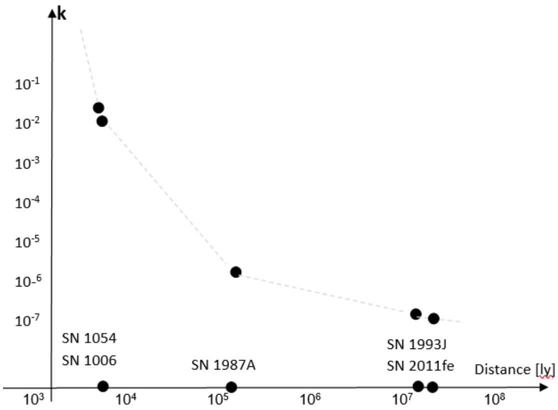

Figure 3. *Estimated coherence parameter k as a function of supernova distance. Both axes are logarithmic. The connecting line is included only as a guide to the eye and does not represent a theoretically derived dependence.*

8. Predicted Spectral Evolution

8.1 Origin of the Prediction

According to the CVDP model, electromagnetic radiation emitted simultaneously by particles possessing different radial velocities reaches the observer in a well-defined temporal sequence.

Radiation emitted by particles moving toward the observer arrives first, followed by radiation emitted by particles having progressively smaller positive radial velocities, zero radial velocity, and finally negative radial velocities.

Consequently, the observed spectrum is expected to evolve systematically throughout the observed duration of the event.

8.2 Expected Spectral Sequence

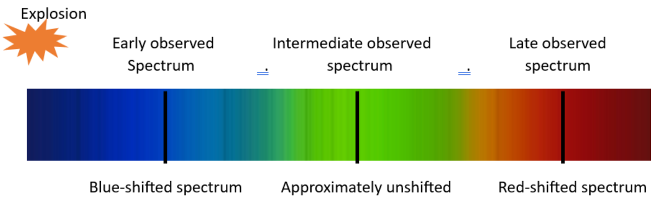

Figure 4. *Predicted temporal spectral ordering in the CVDP model. Radiation associated with positive radial emitter velocities is expected to arrive first and produce a predominantly blue shifted spectrum. Radiation associated with progressively smaller radial velocities follows, passing through an approximately unshifted stage, while radiation associated with negative radial velocities arrives later and produces a predominantly redshifted spectrum. The diagram is schematic and illustrates the predicted temporal evolution of the observed spectrum. It is not intended to represent a calculated spectral line profile or spectral intensity distribution.*

8.3 Physical Interpretation

The predicted spectral evolution does not arise from any change in the physical expansion velocity of the ejecta.

Instead, it results from the temporal ordering of radiation emitted by particles having different radial velocities.

Within the CVDP framework, the spectral evolution is therefore interpreted as a propagation effect rather than solely as a property of the expanding source.

8.4 Relation to Supernova Observations

Many supernovae exhibit evolving spectral line profiles during their optical development.

Within the conventional interpretation, these changes are attributed to the evolution of the expanding ejecta.

The CVDP model offers an alternative interpretation in which part of the observed spectral evolution may arise from the temporal ordering of radiation during propagation.

Further observational investigation is required to distinguish between these possibilities.

8.5 Observational Prediction

If the CVDP model is correct, sufficiently well-sampled spectra of nearby supernovae should exhibit a systematic progression during the observed evolution of the event.

$$\boxed{\text{blue} \rightarrow \text{neutral} \rightarrow \text{red}}$$

Detection or absence of such behaviour would provide a direct observational test of the proposed propagation model.

A systematic blue-to-red progression observed repeatedly in independent supernovae would therefore constitute one of the principal observational predictions of the CVDP model.

The CVDP model therefore makes two principal observational predictions. The first is the propagation-dependent duration described by Equation (6). The second is the temporal evolution of observed spectra from initially blue shifted through nearly unshifted to progressively redshifted radiation. The following chapters discuss the physical consistency of these predictions and possible experimental tests. [7], [8], [13], [14]

9. Energy Conservation

9.1 Motivation

One of the first questions raised by the CVDP model concerns the conservation of energy. Since the proposed model predicts propagation-dependent arrival times and propagation velocities, it is necessary to examine whether these effects imply any creation or loss of electromagnetic energy during propagation.

The CVDP model modifies the predicted arrival times of electromagnetic radiation without proposing the creation or destruction of electromagnetic energy.

Within the framework presented in this paper, the total radiated energy is assumed to remain unchanged. The proposed propagation mechanism affects only the temporal distribution of the arriving radiation.

A detailed physical description of energy transport during coherent propagation is beyond the scope of the present work and remains a subject for future investigation.

10. Observational and Experimental Tests

10.1 General Principle

The CVDP model differs from the conventional interpretation primarily through its observational predictions.

Consequently, the proposed model should be evaluated by comparing its predictions with astronomical observations rather than solely through mathematical analysis.

10.2 Temporal Stretching

Measurements of transient events over a wide range of distances may be used to determine whether the observed duration exhibits the dependence predicted by Equation (6).

In the measurements, we check whether $t_p(d)$ increases as predicted by the CVDP model, or remains unchanged?

10.3 Spectral Evolution

Acquire high-cadence spectra of nearby supernovae throughout their optical evolution.

Determine whether the observed spectra exhibit a systematic temporal progression

predominantly blue shifted ->
approximately unshifted ->
predominantly redshifted

consistent with the CVDP model.

10.4 Comparison with Existing Archives

Extensive spectroscopic archives of nearby supernovae already exist.

Systematic re-analysis of these observations may therefore provide an initial assessment of the predicted temporal spectral ordering without requiring new observational campaigns.

10.5 Laboratory Tests

Although the present paper focuses on astronomical observations, laboratory experiments capable of testing propagation-dependent effects would also be of considerable interest.

The design of such experiments is left for future work.

10.6 Summary

The CVDP model is experimentally distinguishable from the conventional interpretation because it predicts both propagation-dependent temporal stretching and systematic temporal spectral ordering.

These predictions provide a basis for future observational and experimental evaluation. [7], [11], [12]

11. Discussion

11.1 Scope of the Proposed Model

The CVDP model proposed in this paper is intended as a propagation model for electromagnetic radiation emitted during transient astronomical events.

The present work does not attempt to provide a complete reformulation of electromagnetic theory or relativistic physics. Instead, it investigates whether a propagation model based on emitter-dependent initial propagation velocities can account for selected observational properties of supernovae.

11.2 Principal Results

The principal results of the present work are:

- derivation of the CVDP duration equation;
- introduction of the coherence parameter k;
- application of the model to representative supernovae;
- prediction of systematic temporal spectral ordering.

11.3 Limitations

Several simplifying assumptions have been adopted throughout the present analysis.

The intrinsic explosion duration has generally been neglected compared with the observed optical duration.

Characteristic ejecta velocities have been represented by single representative values.

The coherence parameter has been estimated only to order of magnitude.

Accordingly, the numerical estimates presented in this paper should be regarded as exploratory rather than definitive.

11.4 Future Work

Future work may address a more detailed physical description of coherent propagation, improved estimates of the coherence parameter from larger observational samples, and systematic comparison with archived spectroscopic observations of nearby supernovae.

11.5 Final Remarks

The CVDP model introduces a unified framework linking propagation-dependent temporal stretching and temporal spectral evolution.

Whether these predictions provide a better description of nature than the conventional interpretation remains an observational question.

The principal objective of the present work is therefore to formulate quantitative predictions that can be examined by future astronomical observations.

The CVDP model is formulated in a manner that allows its principal predictions to be tested and potentially falsified by future observations.

12. Conclusions

This paper has introduced the Classical Velocity-Dependent Propagation (CVDP) model, in which the initial propagation velocity of an electromagnetic wave is assumed to depend on the radial velocity of the emitting particle at the moment of emission.

Within this framework, a simple expression has been derived for the observed duration of transient astronomical events. Direct application of the model predicts temporal stretching considerably larger than that observed for supernova light curves. To account for this difference, the paper has proposed coherent electromagnetic propagation as a mechanism that reduces the effective propagation-velocity dispersion during propagation. This process is characterized by the coherence parameter k.

Application of the model to representative supernovae indicates that the estimated values of k are much smaller than unity, suggesting substantial reduction of the initial propagation-velocity dispersion.

In addition to propagation-dependent temporal stretching, the CVDP model predicts a systematic temporal evolution of observed spectra, in which predominantly blueshifted radiation is expected to precede approximately unshifted radiation, followed by predominantly redshifted radiation.

The principal contribution of the present work is therefore not the introduction of a complete theory of electromagnetic propagation, but the formulation of a quantitative propagation model that leads to observationally testable predictions.

Future astronomical observations and systematic analyses of existing spectroscopic archives may determine whether these predictions provide a useful description of transient astronomical phenomena

The CVDP model is therefore presented as a quantitative hypothesis whose validity ultimately depends on future astronomical observations.

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