A Diffusive Light-Electron Interaction: Spectral Redshift Effects in Astrophysics

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I. Introduction

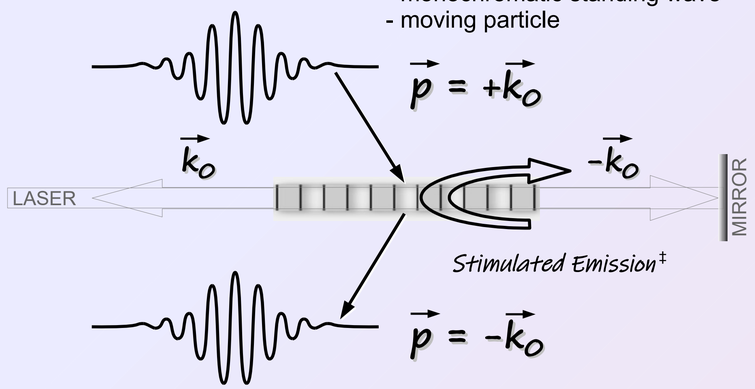
Advances in experimental quantum optics have provided a number of additional tools that we can use to re-examine the possibility that the spectrum of light is shifted toward longer wavelengths during its propagation through the intergalactic medium. The implications of such a spectral redshift suggest a revised analysis of all astrophysical data that has been exclusively interpreted with Doppler, gravitational, or expansion effects as the cause of redshifts.

The ***Stimulated Transfer redshift*** (STz) is a mechanism that is calculable from modern quantum electrodynamics without *"new physics"* or *"some unknown principle of nature"*.[1] The mechanism relies on stimulated emission to produce a spectral redshift while maintaining the wavefront properties of all light beams over cosmic distances.[a] The emerging properties of this mechanism describe a tired-light mechanism that explains astronomical observations.

Misconceptions about tired-light arise from old arguments that have now been superseded by modern quantum theory.

II. Gradient Force – *Theory*

- monochromatic standing wave
- moving particle



A retroreflected light beam forms an interference grating at rest.
The electron-field interaction is[4]

$$\tilde{V}(t) = \frac{e}{m_e}\vec{A}\cdot\boldsymbol{p} = \frac{e}{m_e}\int_{\boldsymbol{p}}\sum_i \mathrm{i}\sqrt{\frac{\hbar}{2\varepsilon_0\omega_i L^3}}\left[\hat{a}_i\, \mathrm{e}^{+\mathrm{i}\vec{\boldsymbol{k}}_i\cdot\vec{\boldsymbol{r}}} + \hat{a}_i^\dagger\, \mathrm{e}^{-\mathrm{i}\vec{\boldsymbol{k}}_i\cdot\vec{\boldsymbol{r}}}\right]\hat{\epsilon}_i\cdot\boldsymbol{p}$$

Properties

- Bragg scattering off a periodic structure
- Stimulated Emission transfers photons to the other mode
- Particle – Photon momentum exchange
- Conservative interaction

Effects

+ *recoil redshift* $\lambda' = \lambda + 4\lambda_e$ *from* $\vec{k}_F$ *to* $\vec{k'}_F$; $\vec{k}_C$ *is unchanged*
+ *electron heating from momentum diffusion*
+ *radiation pressure from momentum* $\vec{k}_F - \vec{k'}_F$ *lost by light*

Density matrix evolution:
power series expansion of Schrödinger equation to 2nd order

$$\Delta\tilde{\rho}(t) = \frac{1}{i\hbar}\int_{t_0}^{t_0+\Delta t} dt\left[\tilde{V}(t),\tilde{\rho}(t_0)\right] - \frac{1}{\hbar^2}\int_{t_0}^{t_0+\Delta t} dt'\int_{t_0}^{t'} dt\left[\tilde{V}(t'),\left[\tilde{V}(t),\tilde{\rho}(t_0)\right]\right]$$

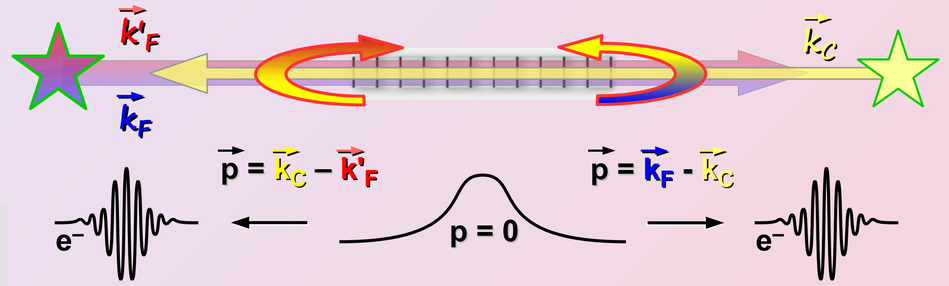
Solution: Rate of transfer *(simplified)*

$$\frac{\Delta\tilde{\rho}(t)}{\Delta t} = \underbrace{\frac{\alpha c\lambda_e\lambda}{2\pi}}_{\text{amplitude}}\int_{\boldsymbol{p},\boldsymbol{p}'}\sum_{i,j}\underbrace{\frac{\sqrt{n_i n_j}}{L^3}}_{\text{n photons}}\mathrm{e}^{+\mathrm{i}[\omega(\boldsymbol{p})-\omega(\boldsymbol{p}')]t_0}\,\mathcal{R}_S(\vec{k}_i,\vec{p})\,\mathcal{R}_A(\vec{k}_j,\vec{p}+\hbar\vec{k}_i)\left[\hat{\epsilon}_i\cdot\hat{p}\right]\left[\hat{\epsilon}_j\cdot(\hat{p}+\hbar\hat{k}_i)\right]\rho(t_0)$$

phase factor $\Phi \approx 2$

III. Gradient Force – *Applications*

- polychromatic travelling waves
- electron[5] in the rest frame of reference



IV. Emerging Properties

+ *Diffusive interaction* ⇒ *energy is lost by the light field* and
  ⇒ *energy is gained by the electron*†
+ Stimulated Emission
  ⇒ *transfers photons to an existing mode*‡ of longer wavelength
+ Momentum transfer to the electron ⇒ *radiation pressure* §
+ Quantized redshift steps ⇒ *broadening of spectral lines at high z*

Redshift from momentum recoil¤ $z_0 = \dfrac{2\lambda_e}{\lambda}$

Transfer rate♯ $\boldsymbol{\Gamma(\rho) \approx \Phi\,\dfrac{\alpha c\lambda_e\lambda}{2\pi}\,\rho}$

+ Produces a wavelength-independent redshift proportional to ρ, the electron density, without blurring images.
+ Simplifying with a uniform ρ, the Hubble-Humason[6] constant is[b]

$$\boldsymbol{H_z = z_0 \times \Gamma(\rho) \approx \frac{\Phi}{\pi}\,\alpha\lambda_e^2 c\,\rho}$$

+ An electron density $\rho = 0.29\ \mathrm{e^-/m^3}$ gives $H_z = 73$ km/s/Mpc.[c]

Observed Macquart relation $z - DM_{EG}$ for FRBs[10] ⇒ $\rho = 0.22^{+0.11}_{-0.13}\ \mathrm{e^-/m^3}$

V. Cosmological Distances

$d_A(z) = \ln(1+z)$	* angular
${}^{GA}d_L(z) = \sqrt{1+z}\,\ln(1+z)$	* galaxy luminosity ◊
${}^{TR}d_L(z) = (1+z)\,\ln(1+z)$	* transient luminosity

VI. Misconceptions about Tired-Light [11]

No interaction can degrade a photon's energy without also changing its momentum,[true] *which leads to a blurring of distant objects.*[false]

The photon's energy is reduced *via stimulated emission* into another, *already existing*[IV‡] light beam.[2] As a result, images of objects are unchanged.

Tired-light models do not predict time dilation of high redshift supernova light curves.[false]

Optical transients transfer photons into the counter-propagating beam which causes temporal feedback that stretches light curves.

Optical processes are all wavelength dependent,[true] *they cannot generate a wavelength-independent redshift.*[false]

The λ-dependence of the stimulated transfer rate[IV♯] cancels the inverse-λ-dependence of the momentum recoil redshift[IV¤].

Tired-light models cannot produce a blackbody spectrum for the Cosmic Microwave Background.[false]

Stimulated transfers produce a *wavelength* redshift that is opposite to the *energy* blue-shift produced by the Sunyaev-Zel'dovich effect in the hot electrons[IV†] of the IGM. At T_{CMB} the two rates are equal in magnitude, and radiation equilibrates to a blackbody spectrum.

T-L fails the Tolman surface brightness test of Lubin & Sandage[12]. [false]

Galaxy properties, such as luminosity and stellar populations, are incorrectly identified since the luminosity resulting from STz[V◊] differs from that calculated with ΛCDM. The Tolman test of Ref. [12] is biased by an incorrect calculation of galaxy luminosity, among other things.

A static universe is unstable against gravity and will collapse.[false]

Radiation pressure[IV§] on the IGM, produced by light-emitting objects, is in a direction opposite to the force of gravity from these objects. The radiation force is stronger than gravity for the most luminous objects.

"*For the above reasons cautiousness requires not to interpret too dogmatically the observed redshifts as caused by an actual expansion.*"[13]

VII. References and Footnotes

[1] p. 21, E.P. Hubble *"The observational approach to cosmology"* Clarendon Press Oxford (1937)
[2] L. Marmet *"Optical forces as a redshift mechanism: the 'Spectral Transfer Redshift' "* Proceedings of the 2nd Crisis in Cosmology Conference, Astronomical Society of the Pacific Conference Series **413**, 268 (2009)
[3] J. Moret-Bailly *"Propagation of light in low-pressure ionized and atomic hydrogen: application to astrophysics"* IEEE Trans. Plasma Sci. **31**(6) 1215 (Dec. 2003) doi: 10.1109/TPS.2003.821476
[4] See e.g. §13 Eq. (7) in *"The Quantum Theory of Radiation"* W. Heitler, Oxford at the Clarendon Press, 3rd edition (1970)
[5] A.V. Gaponov, M.A. Miller *"Potential Wells for Charged Particles in a High-Frequency Electromagnetic Field"* J. Exptl. Theoret. Phys. (U.S.S.R.) **34**, 242 (1958)
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[7] L.E. Ashmore *"Recoil Between Photons and Electrons Leading to the Hubble Constant and CMB"* Galilean Electrodynamics **17**(SI 3) 53 (2006)
[8] R.F. Bonn *"Cosmological Effects of Scattering in the Intergalactic Medium"* Vaughan Publishing (2008), on p. 502
[9] T. Smid *"Plasma Theory of Hubble Redshift of Galaxies"* https://www.plasmaphysics.org.uk/research/redshift.htm
[10] Based on 21 localized FRBs reported in J. Baptista *et al. "Measuring the Variance of the Macquart Relation in Redshift–Extragalactic Dispersion Measure Modeling"* ApJ **965**(1) 57 (2024) doi: 10.3847/1538-4357/ad2705
[11] For example N. Wright *"Errors in Tired Light Cosmology"* https://www.astro.ucla.edu/~wright/tiredlit.htm, R.M.T. White *et al. "The Dark Energy Survey Supernova Program: Slow supernovae show cosmological time dilation out to z~1"* https://arxiv.org/abs/2406.05050, M. López-Corredoira *"Fundamental Ideas in Cosmology"* (2022) doi: 10.1088/978-0-7503-3775-5, and Wikipedia "Tired light" https://en.wikipedia.org/wiki/Tired_light
[12] L.M. Lubin, A. Sandage *"The Tolman Surface Brightness Test for the Reality of the Expansion. IV. A Measurement of the Tolman Signal and the Luminosity Evolution of Early-Type Galaxies"* The Astronomical Journal **122**(3) 1084 (Sept. 1, 2001)
[13] F. Zwicky *"Remarks on the Redshift from Nebulae"* Phys. Rev. **48**(10) 802 (1935) doi: 10.1103/PhysRev.48.802, on p. 803

[a] Of all proposed tired-light mechanisms, only Refs. [2, 3] are based on stimulated emission.
[b] The factor $\alpha\lambda_e^2 c$ is π times larger than $2hr_e/m_e$ as calculated in Ref. [7]. $\lambda_e = 2.4\times10^{-12}$ m is the Compton wavelength.
[c] Of all proposed tired-light mechanisms, only Refs. [2, 7, 8, 9] predict the observed electron density in the IGM.