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Doppler Volume Rendering: A Dynamic, Piecewise Linear Spectral Representation for Visualizing Astrophysics Simulations. Supplemental Material

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1. Accumulation Cases

The mathematical formulation for all the possible 11 accumulation cases of $f(x)$ and $g(x)$ piecewise linear functions is as follows:

Case	Accumulation	Case	Accumulation
Case 1 or 11: $x_2 < y_1 \vee y_2 < x_1$	$f(x)+g(x) = \begin{cases} m_1x+b_1 & x_1 \le x \le x_2 \\ m_2x+b_2 & y_1 \le x \le y_2 \\ 0, & \text{else} \end{cases}$	Case 2: $x_1 < y_1 < x_2 < y_2$	$f(x)+g(x) = \begin{cases} m_1x+b_1 & x_1 \le x \le y_1 \\ (m_1+m_2)x+(b_1+b_2) & y_1 < x \le x_2 \\ m_2x+b_2 & x_2 < x \le y_2 \\ 0, & \text{else} \end{cases}$
Case 3: $y_1 < x_1 < y_2 < x_2$	$f(x)+g(x) = \begin{cases} m_2x+b_2 & y_1 \le x \le x_1 \\ (m_1+m_2)x+(b_1+b_2) & x_1 < x \le y_2 \\ m_1x+b_1 & y_2 < x \le x_2 \\ 0, & \text{else} \end{cases}$	Case 4: $x_1 < y_1 < x_2 = y_2$	$f(x)+g(x) = \begin{cases} m_1x+b_1 & x_1 \le x \le y_1 \\ (m_1+m_2)x+(b_1+b_2) & y_1 < x \le y_2 \\ 0, & \text{else} \end{cases}$
Case 5: $x_1 = y_1 < x_2 = y_2$	$f(x)+g(x) = \begin{cases} (m_1+m_2)x+(b_1+b_2), & x_1 \le x \le x_2 \\ 0, & \text{else} \end{cases}$	Case 6: $y_1 < x_1 < x_2 = y_2$	$f(x)+g(x) = \begin{cases} m_2x+b_2 & y_1 \le x \le x_1 \\ (m_1+m_2)x+(b_1+b_2) & x_1 < x \le y_2 \\ 0, & \text{else} \end{cases}$
Case 7: $x_1 = y_1 < x_2 < y_2$	$f(x)+g(x) = \begin{cases} (m_1+m_2)x+(b_1+b_2) & x_1 \le x \le x_2 \\ m_2x+b_2 & x_2 < x \le y_2 \\ 0, & \text{else} \end{cases}$	Case 8: $x_1 = y_1 < x_2 < y_2$	$f(x)+g(x) = \begin{cases} (m_1+m_2)x+(b_1+b_2) & x_1 \le x \le y_2 \\ m_1x+b_1 & y_2 < x \le x_2 \\ 0, & \text{else} \end{cases}$
Case 9: $x_1 < y_1 < y_2 < x_2$	$f(x)+g(x) = \begin{cases} m_1x+b_1 & x_1 \le x \le y_1 \\ (m_1+m_2)x+(b_1+b_2) & y_1 < x \le y_2 \\ m_1x+b_1 & y_2 < x \le x_2 \\ 0, & \text{else} \end{cases}$	Case 10: $y_1 < x_1 < x_2 < y_2$	$f(x)+g(x) = \begin{cases} m_2x+b_2 & y_1 \le x \le x_1 \\ (m_1+m_2)x+(b_1+b_2) & x_1 < x \le x_2 \\ m_2x+b_2 & x_2 < x \le y_2 \\ 0, & \text{else} \end{cases}$

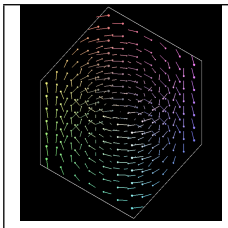
2. Galaxy Dataset Information

Additional information of the Galaxy dataset, simulating the asymmetries of the center of the Milky Way, by Sormani et al.:

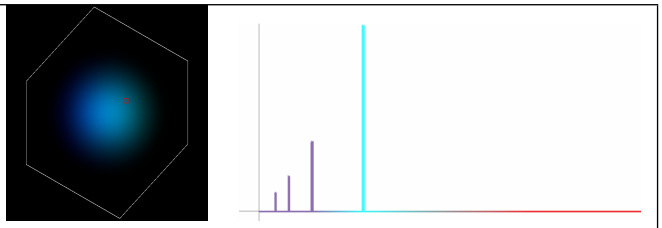
Density range	$\rho \in [7.65 \times 10^{-26}\,\mathrm{g/cm^3}, 1.94 \times 10^{-15}\,\mathrm{g/cm^3}]$ $\rho_{q=0.05} = 8.1 \times 10^{-23}\,\mathrm{g/cm^3}$, $\rho_{q=0.95} = 3.16 \times 10^{-20}\,\mathrm{g/cm^3}$
Gas temperature range	$T \in [130.7\,\mathrm{K}, 481.1\,\mathrm{K}]$ $T_{q=0.05} = 439.0\,\mathrm{K}$, $T_{q=0.95} = 480.9\,\mathrm{K}$
Velocity ranges	$v_x \in [-342, 328]$ km/s, $v_y \in [-238, 242]$ km/s, $v_z \in [-140, 117]$ km/s $v_{x,q=0.05} = -267\,\mathrm{km/s}$, $v_{x,q=0.95} = 267\,\mathrm{km/s}$ $v_{y,q=0.05} = -200.0\,\mathrm{km/s}$, $v_{y,q=0.95} = 200\,\mathrm{km/s}$ $v_{z,q=0.05} = -10.0\,\mathrm{km/s}$, $v_{z,q=0.95} = 9.39\,\mathrm{km/s}$ (Compare Speed-of-light $c = 299\,792.458\,\mathrm{km/s}$)
Matter included	neutral hydrogen HI molecular hydrogen H_2 carbon monoxide CO

3. Synthetic Dataset

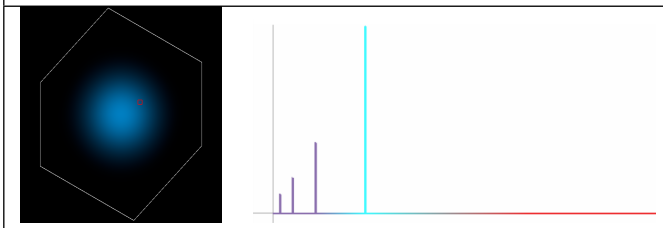
With the aim of evaluating our technique in a controlled environment, we created a synthetic dataset, consisting of a radial density field of hydrogen, moved by a vector field with cylindrical dynamics, of thickness around 10% of the side of the volume. The figure shows two sample spectra along respective rays traversing the velocity field.



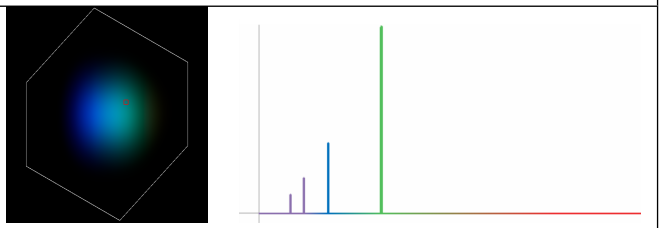
Vector field of the velocities.



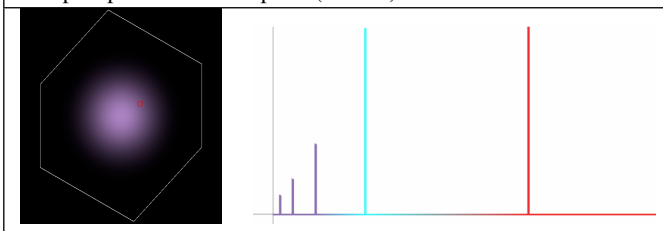
Doppler effect with velocity $\times 1$.



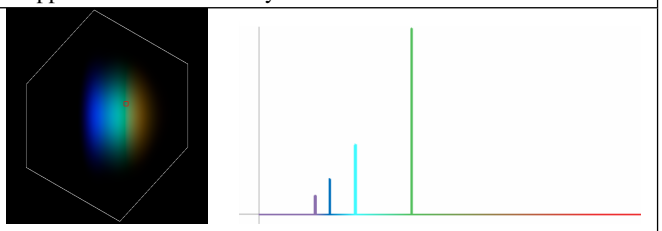
Sample spectrum from a pixel (red dot) in normal conditions.



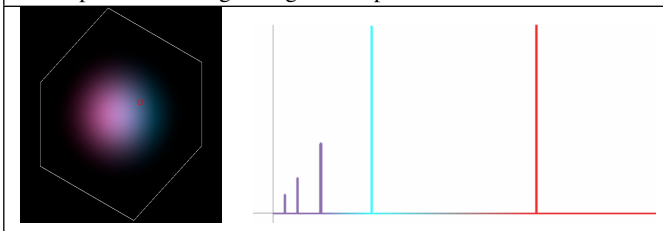
Doppler effect with velocity $\times 5$.



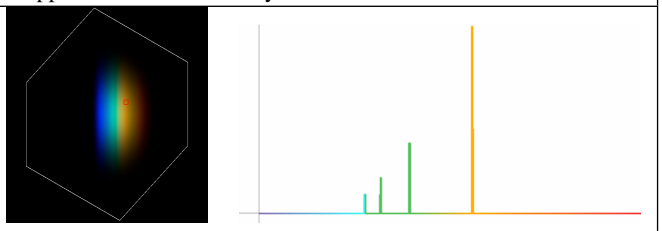
Same pixel cancelling the light absorption.



Doppler effect with velocity $\times 10$.



Same pixel, with Doppler effect and without light absorption.



Doppler effect with velocity $\times 20$.