MNRAS 000, 1–1 (2024) Preprint December 12, 2024 Compiled using MNRAS LATEX style file v3.2

Temperature fluctuations in turbulent H II regions I. Large-scale radiative shocks

William J. Henney[1⋆], J. García-Vázquez[2], S. J. Arthur[1], Sac-Nicté X. Medina[3], and others?
[1]*Instituto de Radioastronomía y Astrofísica, Universidad Nacional Autónoma de México, Apartado Postal 3-72, 58090 Morelia, Michoacán, Mexico*
[2]*Escuela Superior de Física y Matemáticas, Instituto Politécnico Nacional, U.P. Adolfo López Mateos, Zacatenco, Ciudad de México, México C.P. 07738*
[3]*German Aerospace Center, Scientific Information, 51147, Cologne, Germany; Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121, Bonn, Germany*

Accepted XXX. Received YYY; in original form ZZZ

ABSTRACT
Turbulence can cause temperature fluctuations via two mechanisms in H II regions, via a direct mechanism, and by an indirect mechanism. In the direct mechanism, dissipation of the turbulent kinetic energy acts as a fluctuating heating source for the gas. In the indirect mechanism, the shocks cause density fluctuations, which modulate the ionizing flux that arrives at the outer parts of the H II region, causing the boundary to move in and out, transitioning between a recombination front and an ionization front. If the modulation timescale corresponds to the recombination timescale, then a portion of the gas is out of thermal equilibrium.

Key words: HII regions – ISM: kinematics and dynamics – turbulence

1 INTRODUCTION

There are reasons to be suspicious of the high temperatures in ionization transition zones seen in Figure 1a. The non-local effects of the diffuse ionizing radiation field are not considered in the simulation and the atomic physics of the heating and cooling processes are treated in a very approximate way (Henney et al. 2009).

2 SUMMARY OF GARCÍA-VÁZQUEZ ET AL. (2023)

DATA AVAILABILITY STATEMENT

All data and accompanying analysis programs used in this paper are available from the github repository `https://github.com/will-henney/turb-t2-paper`.

References

Henney W. J., Arthur S. J., de Colle F., Mellema G., 2009, MNRAS, 398, 157
Medina S.-N., Arthur S., Henney W., Mellema G., Gazol A., 2014, MNRAS, 445, 1797

APPENDIX A: CLOUDY MODELS OF LOW-VELOCITY SHOCKS IN H II REGIONS

This paper has been typeset from a TEX/LATEX file prepared by the author.

⋆ w.henney@irya.unam.mx

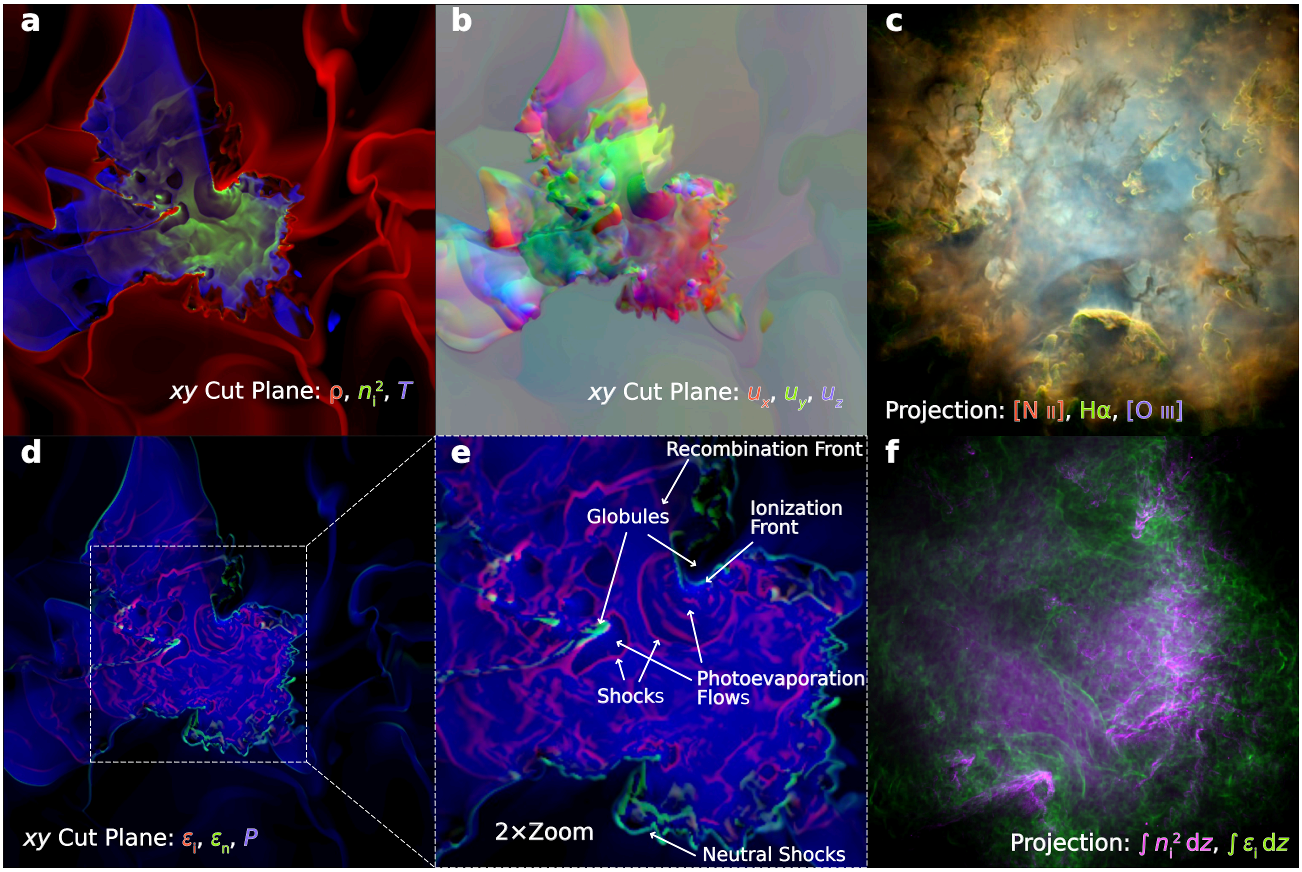

Figure 1. Structure of a single-star H II region from a three-dimensional radiation-hydrodynamics simulation (Medina et al. 2014). (a) Plane xy cut through the fields of gas density (red), squared ionized density (green), and gas temperature (blue). (b) Vector velocity field for the same cut: red, green, blue show u_x, u_y, u_z, with dark colors indicating negative values and light colors positive values. Mid gray indicates zero. (c) Simulated surface brightness image of the simulation cube in 3 different optical emission lines: [N II] λ6584 (red), Hα λ6563 (green), and [O III] λ5007 (blue). (d) Same cut plane as (a), but showing the kinetic energy dissipation rate ϵ for ionized gas (red) and neutral gas (green), together with the thermal gas pressure (blue). (e) Zoom of central portion of panel (e), with labeling of different features (see test for details). (f) Projection along the line of sight of the ionized emission measure $\int n_i^2\, dz$ (green) and the integrated kinetic energy dissipation rate $\int \epsilon_i\, dz$ (purple).