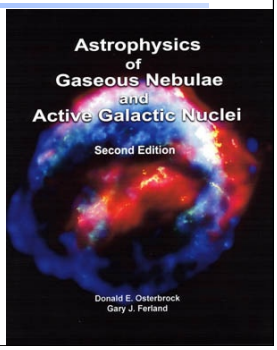
Spectrum of a non-equilibrium gas

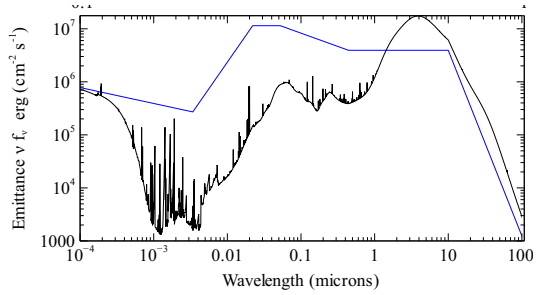
- **Detailed microphysics**
- **Energetic radiation & particles interact with gas**
- **Ejected electrons heats, excite & ionize gas**
- **Ionization drives chemistry**
- **Full spectrum predicted**
  - Detailed chemistry, grain physics



Model atoms with self-consistent interactions with environment

- **Many-level atom solvers within Cloudy**
  - Fe II with ~10^3 levels
  - H_2 with ~10^5 levels
  - Lamda molecular data base Schoeier+05
  - Chianti ionic data base Dere+09
- **Self consistent with environment**
  - Collisional effects
  - Line optical depths
  - Photon pumping
  - Line absorption by continuous opacities

AGN spectrum



The He-like iso-sequence

- **He I, remainder of He-iso sequence**
  - Porter PhD, Porter & Ferland 07

REVISITING He-LIKE X-RAY EMISSION-LINE PLASMA DIAGNOSTICS

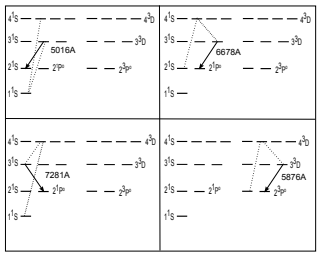
R. L. Porter and G. J. Ferland

- **Adjustable number of levels**
- **Constantly improved atomic data**
- **"single zone" with very large atom**
  - Specified kinetic temperature and density
- **Within self-consistent model of nebula, with modest number of levels**

Case A, B, C, D

FLUORESCENT EXCITATION OF BALMER LINES IN GASEOUS NEBULAE: CASE D

V. Luridiana[1], S. Simón-Díaz[2], M. Cerviño[3], R. M. González Delgado[3], R. L. Porter[4], and G. J. Ferland[4]

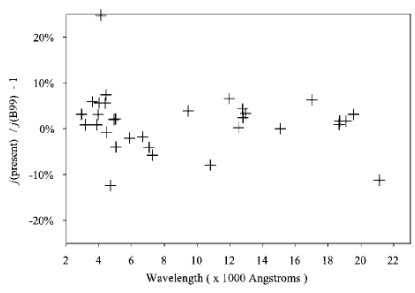


Luridiana+09

Paper 1 Case B, Porter+05

THEORETICAL He I EMISSIVITIES IN THE CASE B APPROXIMATION

R. L. Porter, R. P. Bauman, G. J. Ferland, and K. B. MacAdam



Paper 2, single triplet mixing

J-RESOLVED He I EMISSION PREDICTIONS IN THE LOW-DENSITY LIMIT

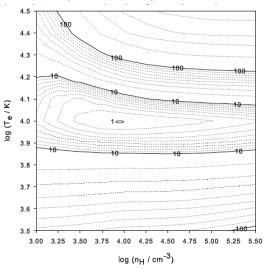
R. P. Bauman, R. L. Porter, G. J. Ferland, and K. B. MacAdam

Bauman+05

Conditions in Orion Nebula

He I EMISSION IN THE ORION NEBULA AND IMPLICATIONS FOR PRIMORDIAL HELIUM ABUNDANCE

R. L. Porter, G. J. Ferland, and K. B. MacAdam



Porter+07

Uncertainties

Uncertainties in theoretical He I emissivities: H II regions, primordial abundance and cosmological recombination

R. L. Porter,[1,2]* G. J. Ferland,[1,2] K. B. MacAdam[1] and P. J. Storey[3]

- **Porter+09**

Individual uncertainties

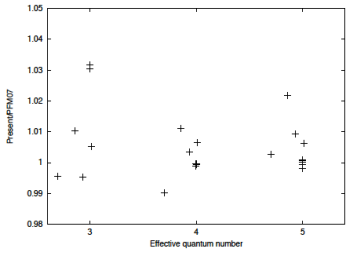
Table 1. Assumed uncertainties in helium atomic data.

Conditions	Optimistic (per cent)	Pessimistic (per cent)
Rad. recomb. coefficients (direct)		
$n >= 5$ and $L > 3$	0	0.1
$n >= 5$ and $L <= 3$	0.01-0.7	≤4
$n < 5$	0.01-0.7	≤4
E1 transition probabilities		
$n_u, n_l < 10$ and $L < 7$	0.01	0.2
$n_u, n_l < 10$ and $L >= 7$	0	0.01
$n_u > 10, n_l < 5$ and $L_l <= 2$	0.02	0.2
$n_u > 10, L_u \geq 2$ and $L_l \geq 2$	0.6	4
$n_u > 10, n_l < 10$ other	1	7
$n_u, n_l > 10$	10	10
Other transition probabilities		
$2p\,^3P_1 - 1s\,^1S$	1	5
$2p\,^3P_2 - 1s\,^1S$	1	1
$2s\,^3S - 1s\,^1S$ (2ν)	10	30
$2s\,^3S - 1s\,^1S$ (M1)	1	20
$2s\,^1S - 1s\,^1S$	1	5
All others	1	1
Collisional de-excitation		
$n_u <= 5$ and $n_l <= 2$	10	30
$\Delta n = 0$	20	30
Otherwise	20	30

Optimistic case 2% errors
Pessimistic case 7% errors

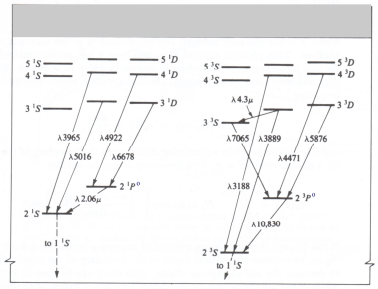
Improved recombination coefficients

- **Porter et al. in preparation**
- **Storey & Hummer photoionization cross sections**



He I in H II regions

- **Detisch et al. in preparation**



He I in H II regions

- Detisch et al. in preparation