Diagnostics using electrodeless lamps

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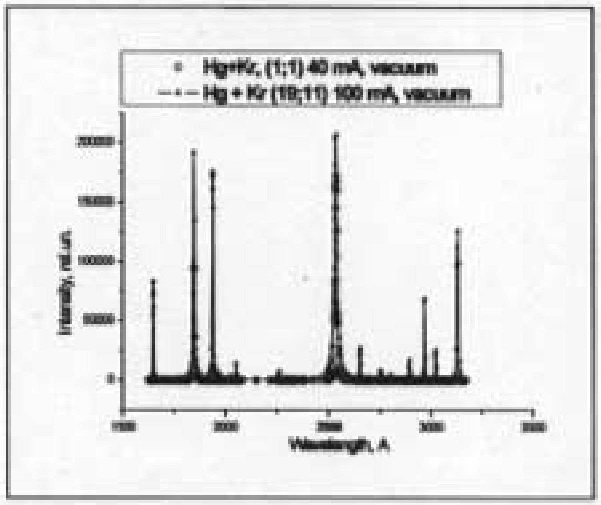
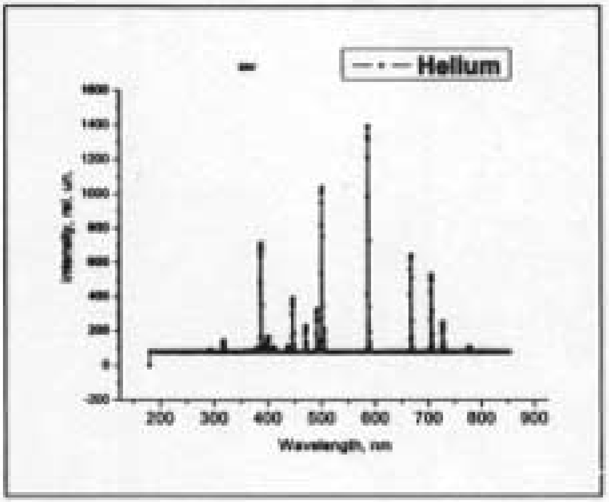
Electrodeless lamps:

- Bright radiators in the broad spectral range (VUV - IR);

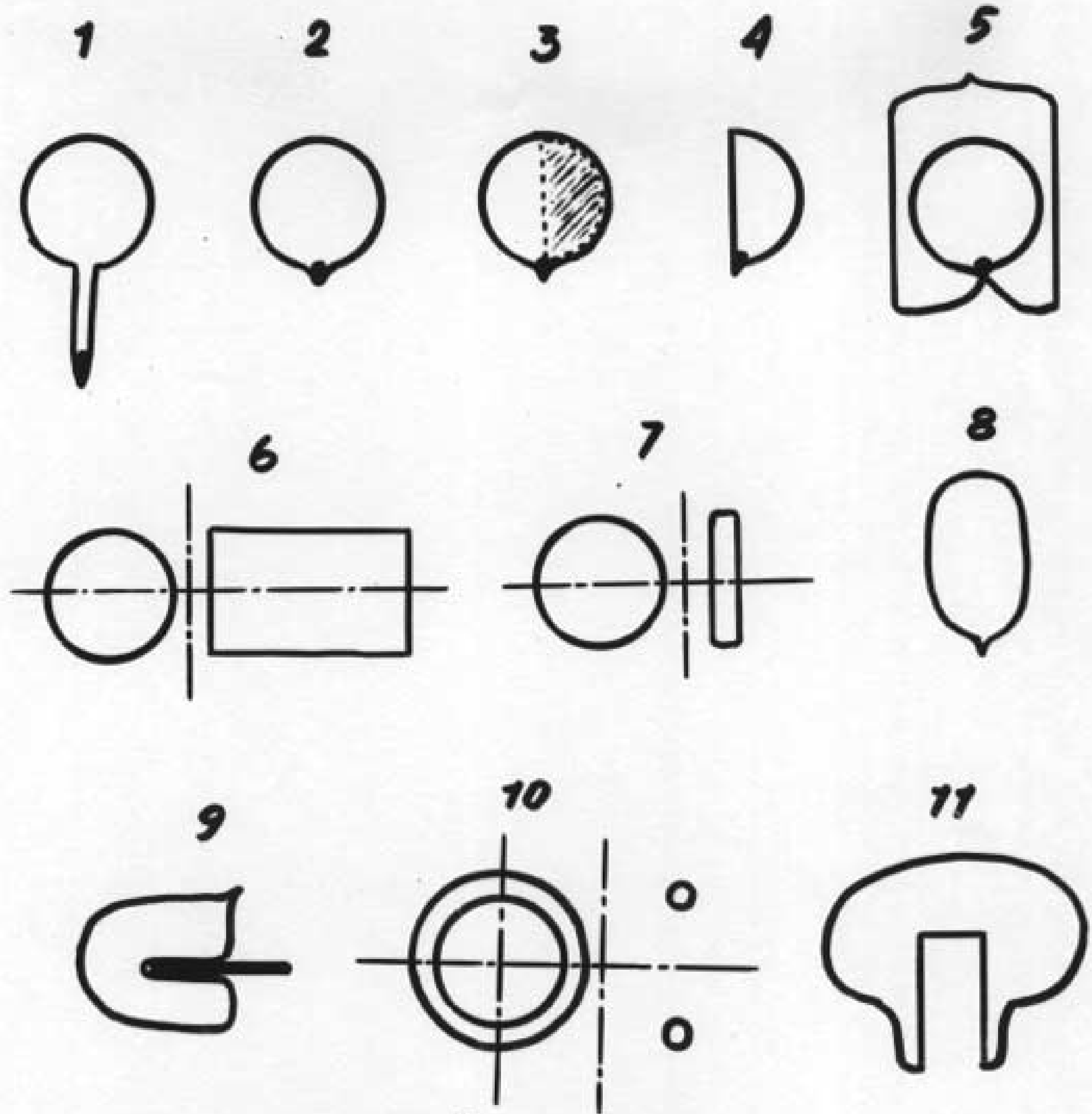




- Filled with a metal vapor and buffer gas;
- No electrodes – long working life;
- Inductive coupled/ capacitance coupled;
- HF Electromagnetic field excitation;
- Different designs and types in dependence on application

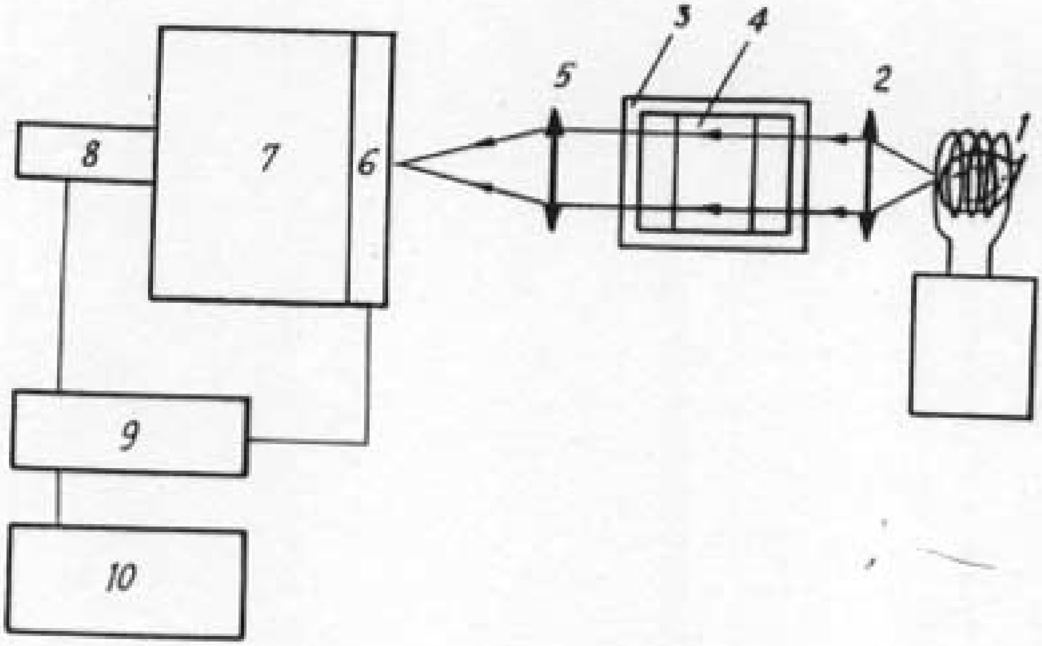
Our experience and technology:

- Lamps containing such elements as ***Sn, Cd, Hg, Zn, Pb, As, Sb, Bi, Fe, Tl, In, Se, Te, Rb, Cs,*** I_2, H_2, ***He, Ne, Ar, Kr, Xe*** as well as combined ***Hg-Cd, Hg-Zn, Hg-Cd-Zn, Se-Te etc***

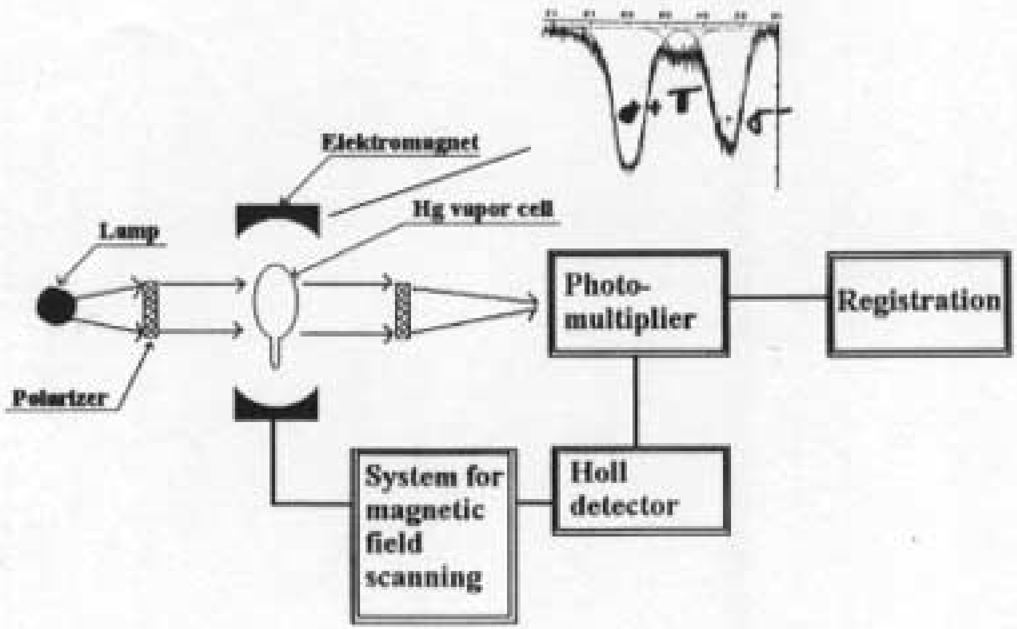


He, H_2, Cd, Zn, Se, Te, Hg, Ar
Pb, Rb, Cs, Tl, Na, K, Ne, Xe, Kr
Sn, Cr, Fe, Ni, Bi, Au, J_2,

Scanning Fabry-Perrot interferometer



Zeeman spectrometer



Theoretical model

bserved spectral line profile: $f(x)=\int_{-\infty}^{+\infty} f''(x-y)f'(y)dy+\xi(x)$, where $f''(x)$ - real profile, $f'(y)$ - nstrumental function, $\xi(x)$ - function characterising random errors.

1) $$G(\nu-\nu_0)=I_0\exp\left[-4\ln 2\left(\frac{\nu-\nu_0}{\Delta\nu_G}\right)^2\right]$$; Gaussian shape
$$\Delta\nu_G=7{,}16\cdot 10^{-7}\frac{1}{\lambda}\sqrt{\frac{T}{\mu}}$$

2) $$L(\nu-\nu_0)=\frac{\Delta\nu_L/\pi}{\left(4(\nu-\nu_0)^2+\Delta\nu_L{}^2\right)}$$ $\Delta\nu_L=\Delta\nu_{nat}+\Delta\nu_{coll}+\Delta\nu_{res}$. Lorentzian shape

3) $$V(a,\omega)=\frac{a}{\pi}\int_{-\infty}^{+\infty}\frac{\exp(-y^2)dy}{a^2+(\omega-y)^2}$$, where $a=\frac{\Delta\nu_L}{\Delta\nu_G}\sqrt{\ln 2}$, $\omega=\frac{2(\nu-\nu_0)\cdot\sqrt{\ln 2}}{\Delta\nu_G}$
$$y=(\nu-\nu')\sqrt{\ln 2/\Delta\nu_G}$$ Voigt profile

4) self-absorption , $\bar{n}_e(r)=\frac{n}{2}\bar{n}_a(r)\left[\int_{|r|}^{\infty}\bar{n}_a(x)dx\right]^{n-1}$; $\bar{n}_a(r)=\frac{n_a(r)}{N_a}$; $\bar{n}_e=\frac{n_e(r)}{N_e}$; $E(y)=\frac{\bar{n}_e(r)}{\bar{n}_a(r)}$

$$E(y)=\begin{cases}\frac{n}{2}y^{n-1}, 0<y<1\\ \frac{n}{2}(2-y)^{n-1}, 1<y<2\end{cases}$$ - Excitation function, $y=\int_r^{\infty}\bar{n}_a(x)dx$ - relative number of atoms capable of bsorbing the line present per unit cross-section between the point under consideration and the outside of the ource

$$I(\omega)=I_0P(\omega)e^{-\mu}\sum_{j=0}^{\infty}\frac{n!\,\mu^{2j}}{(2j+n)!};\qquad \mu=k_0l*\frac{P(\omega)}{P(0)}$$, $n\in Z$, $P(\omega)=V(\omega$ by $a=const$, k_0l - optical density

$$I(\omega)=\frac{I_0P(\omega)}{2k_0l}\left\{1-\exp\left(-k_0l\frac{P(\omega)}{P(0)}\right)\right\}$$, if $n=1$ homogenous radiation source

$$I(\omega)=I_0P(\omega)\exp\left\{-k_0l\frac{P(\omega)}{P(0)}\right\}$$, if $n\to\infty$ completely inhomogenous radiation source

5) Manifold of HFS components having intensities $I_1, I_2,\ldots, I_k$

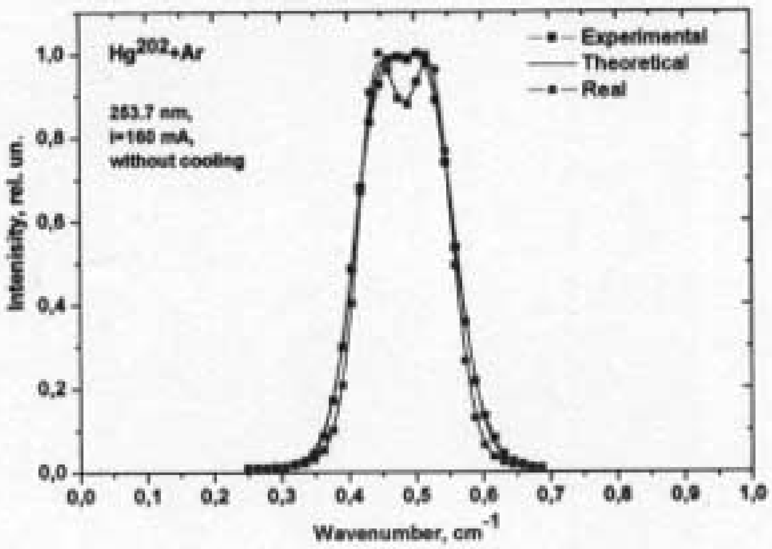
6) Instrument function a) $$I=I_0\frac{1}{1+\frac{4R}{(1-R)^2}\cdot\sin^2\frac{\delta}{2}},\qquad \delta=2\pi\frac{\Delta}{\lambda}$$, Δ- opt. diff. of interfering rays

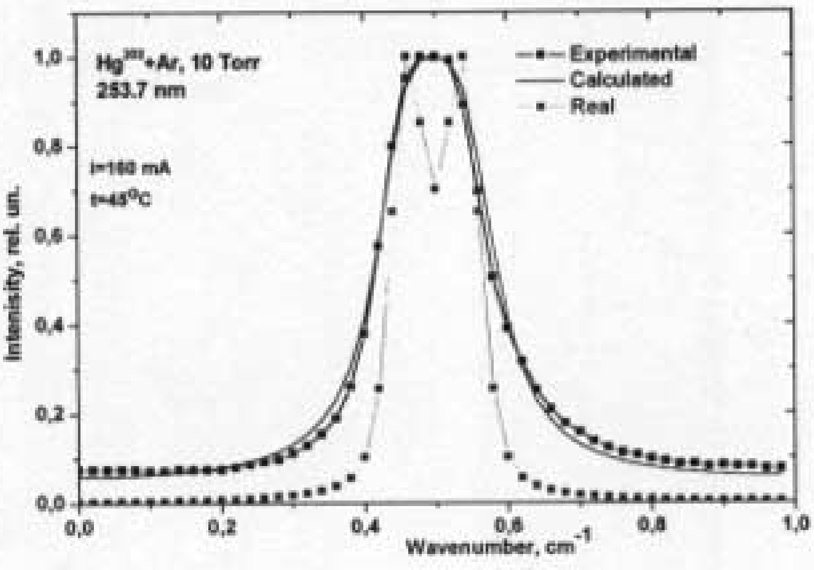
b) Gaussian for Zeeman spectrometer c) numerical or other…

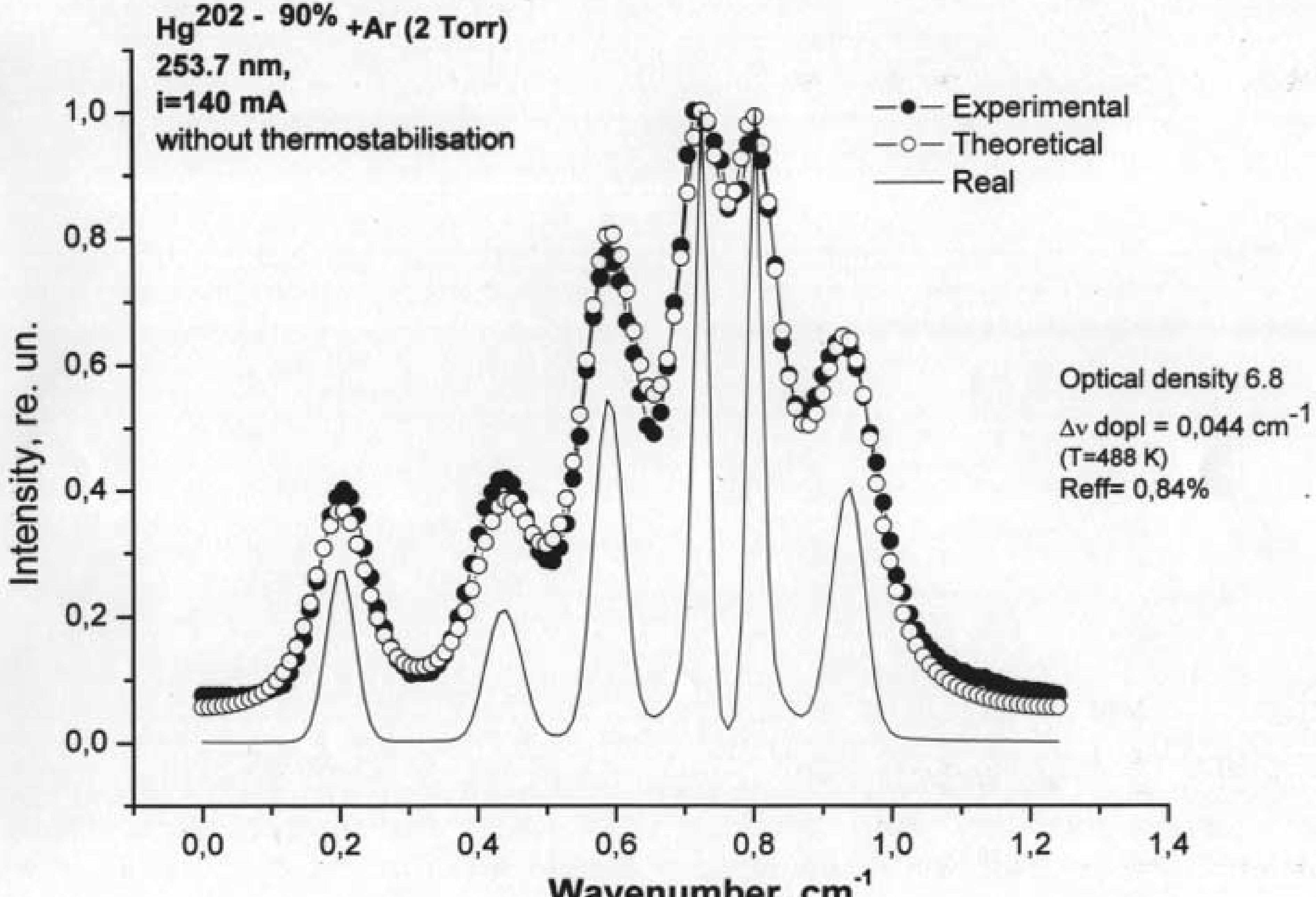
7) Generation of random errors $\xi(x)$.

8) Fitting using $\chi^2=\sum_{i=1}^{n}\frac{1}{\sigma^2}(y_i-f(x_i))^2$ y_i - experimental, $f(x_i)$ - theoretical data

9) $\Delta\nu_G$, $\Delta\nu_L$, k_0l, n, R, $\to \Delta\nu_{int}$
intensities and shifts


Experimental
Theoretical
Real
Hg202+Ar
253.7 nm,
i=160 mA,
without cooling
Intenisity, rel. un.
Wavenumber, cm-1

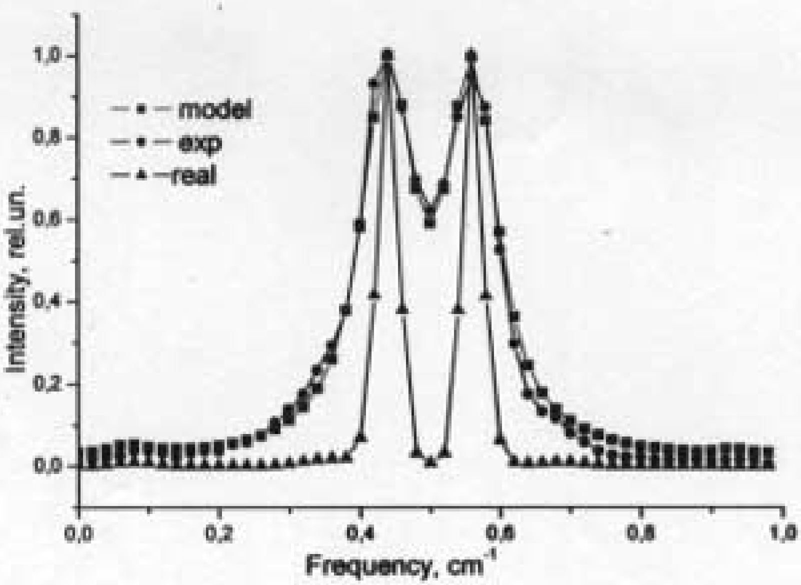

Experimental
Calculated
Real
Hg202+Ar, 10 Torr
253.7 nm
i=160 mA
t=45°C
Intenisity, rel. un.
Wavenumber, cm-1



Hg202 - 90% +Ar (2 Torr)
253.7 nm,
i=140 mA
without thermostabilisation
Experimental
Theoretical
Real
Optical density 6.8
Δν dopl = 0,044 cm-1
(T=488 K)
Reff= 0,84%
Intensity, re. un.
Wavenumber, cm-1
0,0
0,2
0,4
0,6
0,8
1,0
1,2
1,4

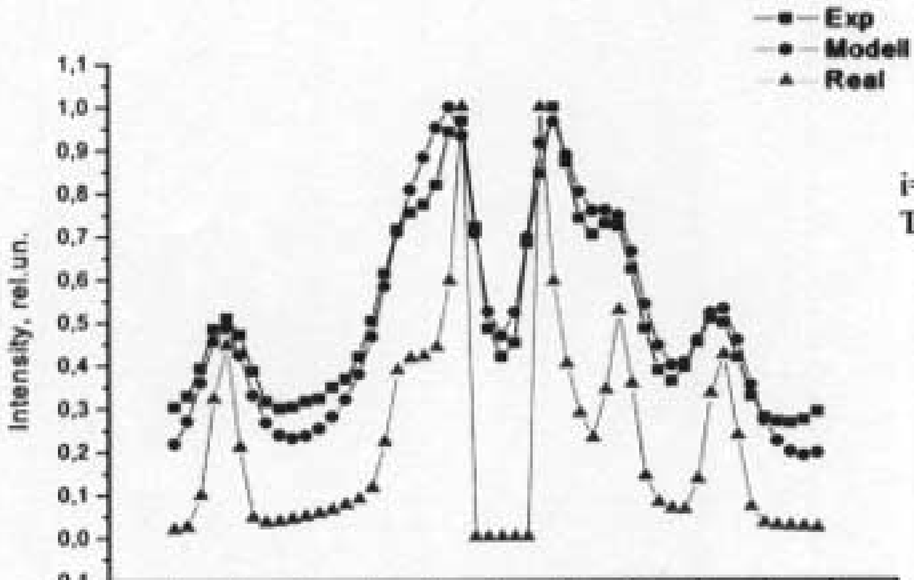
Example

Hg 202 – 99.8 % ; 253.7 nm line, with Hg vapor pressure control



i=160 mA

$T_{Cold\ spot}$ =72° C



i=50 mA

$T_{Cold\ spot}$ =72° C