§32. Development of Two Dimensional Ion Doppler Velocity Measurements

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For the past five years, we have been developing a new visible-light tomography system for two dimensional (2-D) measurements of ion temperature and velocity. In 2007, 1) we increased projection number to 100 and 2) studied a new reconstruction error for 2-D plasma velocity measurement. We reconstructed the local 2-D plasma velocity profile from the measured line-integrated line spectrum with Doppler shift. The 2-D plasma velocity profile is composed of two components as shown in
$\mathbf{v} = \nabla \times \psi + \nabla \phi$ ------------(1),
so that we obtain the following Radon transformation form:

$$R\{\zeta\}(u,\eta) = -\int_{-\infty}^{u} \mathbf{v}\{\theta\}(u',\eta)du' \text{-----------(2)},$$

based on an assumption that our plasma is incompressible as $\nabla \bullet \mathbf{v} = 0$. We solved the equation (2) using the maximum entropy method. Figure 1 shows the 2-D velocity profiles (vectors plot) and assumed and reconstructed toroidal velocity profiles of low aspect ratio toroid. They indicate that the assumed 2-D velocity profile was reconstructed successfully within the error of 20%. Figure 2 shows dependence of the reconstruction error on projection number. Artificially, 10% white noises (n=1 component) were added to the line-integrated signals of line spectrum. It was found that the optimized projection number is about 12-18. Figure 3 top shows the HeII line spectrums measured for three projections. Based on those data, radial velocity profile of two merging spheromaks with counter helicity were calculated as shown in Fig. 3 bottom. The bipolar toroidal velocity by the counter helicity reconnection was reconstructed successfully using our 1-D velocity measurement system.

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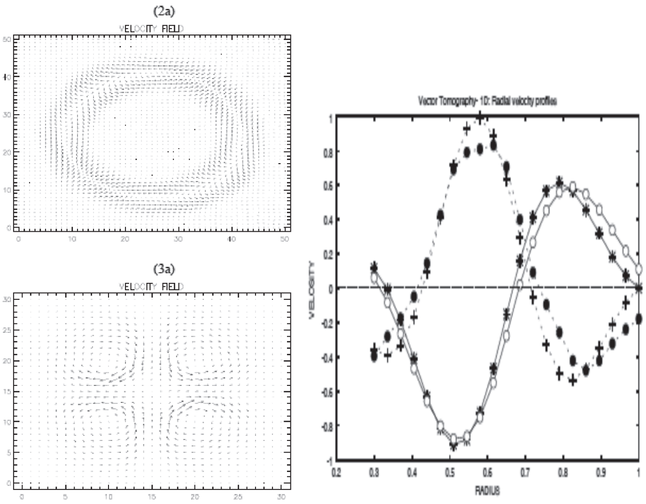

Fig. 1 Two examples of plasma flow reconstruction when they have radial flow shears (top and middle) and comparison of the original velocity profiles and the reconstructed ones where + and ● are the original and reconstructed values, respectively (bottom).

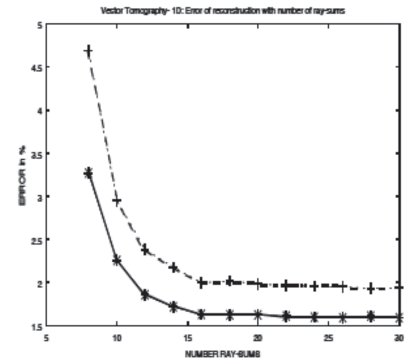

Fig. 2 Errors of reconstructed values as a function of projection number when 10% white noise is applied to the measured projection signals (+ : type 1 flow. ●:type 2 flow).

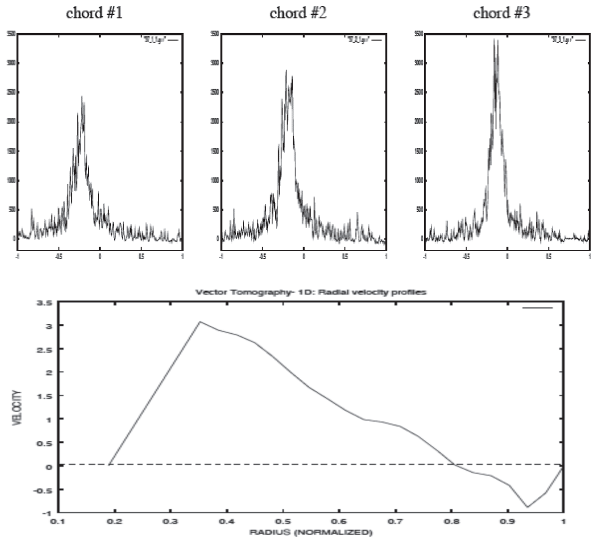

Fig. 3 Examples of HeII spectrums measured by 2-D Doppler diagnostics (top) and the radial velocity profile reconstructed from those data (bottom).